# Examining the Role of Individual Differences within the Experience and Expression of Anger

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# Abstract

Anger is a universal emotion, existing in both state and trait dimensions, that is experienced by most people several times per day to several times per week. Anger is thought to have evolved as a means to recalibrate situations to more align with an individual's goals or motivations. However, inappropriate or excessive anger is related to a host of severe intrapersonal and interpersonal consequences. The current thesis addresses gaps in the empirical literature and investigates how anger and the closely related constructs of hostility and aggression associate with individual differences across multiple domains. Firstly, using data from a nationally-representative US sample, the current thesis presents evidence of both direct effects of and interactions amongst core personality traits on the pathway towards trait anger and anger expression styles. Specifically, results reveal that conscientiousness moderates neuroticism's effect on an individual's ability to control their anger, and, in a three-way interaction, conscientiousness and agreeableness moderate neuroticism's effect on an individual's level of trait anger, the likelihood that anger is expressed outwardly, and the likelihood of aggression. Secondly, the current thesis presents evidence of associations between core personality traits and judgments of hostile intent, and the mediating effect of higher-order personality characteristics. Notably, results indicate that an inflated sense of self-entitlement and the social projection of one's own traits onto others mediated honesty-humility's relationship with a factor underlying judgments of hostile intent. Thirdly, using voxel-based morphometry the thesis presents evidence, albeit at the uncorrected level, of correlations between cortical regions' gray matter and trait anger and anger expression style. Finally, the thesis concludes by embedding these results in the context of prior research investigating the experience of anger and contemporary models of anger and its expression.

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For my family

# Chapter 1

## Individual differences and the experience of anger: An overview

Anger, as a universal emotion (Elfenbein & Ambady, 2002), is experienced by most people at mild to moderate levels several times per day to several times per week (Frost & Averill, 1982, p. 1146). Used constructively, anger can change bring about change such as correcting or preventing future occurrences of others' inappropriate behaviour (Sell, Tooby, & Cosmides, 2009). However, maladaptive, inappropriate, or excessive anger relates to severe intrapersonal and interpersonal consequences such as increased rates of domestic violence (Pan, Neidig, & O'Leary, 1994) and heart disease (Spielberger, 1988). Despite the broadly reaching implications of this affective experience, research has only recently begun unpacking the multiple layers and components involved with the experience and expression of anger.

### Defining anger

Some of the earliest attempts at defining anger were taken from behavioural observations of humans and other animals. Referencing Joseph Butler (1692-1752), Hughes (2001, p. 67) outlines three types of anger: 1) impulsive, as a response to being tormented or trapped, 2) deliberate, as a response to beliefs regarding how one is treated by others, and 3) dispositional, defined by irritability and sullenness. Hughes notes that the first and second forms of anger are largely episodic, occurring in response to specific situations, whereas the third form is dispositional, considered a character trait rather than an acute cognitive process. This observed distinction between episodic and dispositional forms of anger will carry into modern research observing the difference between state and trait anger.

Early empirical attempts to define anger did so by measuring physiological arousal at the state level (Ax, 1953; Funkenstein, King, & Drolette, 1954). These investigations found that increased heart rate, skin conductance, and respiration rate were all related to self-reported states of anger. While useful, these early investigations failed (through no fault of their own) to address two key issues. Firstly, although anger was noted to be physiologically distinguishable from fear (Ax, 1953), these investigations were unable to dissociate anger from other affective states of arousal, such as anxiety. Secondly, measuring the physiological effects related to reactive anger did very little to account for processes that relate to dispositional or trait-level anger. In order to expand the conceptualization and measurement of anger to include cognitive aspects and the stable and long-term trait aspect, researchers began looking at the individual differences related to the experience of anger, rather than just the behavioural expressions (e.g. Buss & Durkee, 1957; Cook & Medley, 1954; Spielberger et al., 1983).

## Measuring anger, hostility, and aggression

Correlations between the distinct constructs of anger, hostility, and aggression (Bushman, Cooper, & Lemke, 1991; Costa, Zonderman, McCrae, & Williams, 1986; Musante, MacDougall, Dembroski, & Costa, 1989) often make distinguishing between them at an operational level somewhat difficult (Miller et al., 1996). The affective and physiological experience of anger may be expressed as either a state, or trait dimension. Whilst anger is considered an intrapersonal affect, hostility is viewed as "other-directed" and is analogous to cognition (Martin et al., 2000). Hostility is related to having a cynical view of the world and others, containing the components of suspicion and resentment (Buss & Perry, 1992). Aggression possesses several aspects, itself: reactive, proactive, and relational (Miller et al., 2012). Reactive aggression is committed in an attempt to return an individual's state of

arousal to that of relative equilibrium. Proactive (instrumental) aggression is conducted in a self-serving manner. Relational aggression is defined as behaviour with the intent of harming another individual's social standing. Buss and Perry (1992) suggest that anger's correlation with the components hostility and aggression provides evidence of its function as a "psychological bridge" between cognitive and instrumental (behavioural) components.

There are numerous established anger and aggression measures throughout the literature. Several of the more prominent measures will be reviewed here, along with any reporting of how they relate to personality traits and other measures of anger, hostility, and aggression. Review of the related literature reveals that the observed relationship between personality and anger and aggression depends largely on the specific facets of anger and aggression being measured by the scales. For example, a scale examining the affective or cognitive components will reveal a strong relation with neuroticism, while scales examining aggressive behaviour towards others will bear a stronger relationship with agreeableness. The variety of scales and the facets they measure help garner a more comprehensive understanding of the variance in experience and expressions of anger and aggression.

**State-Trait Anger Expression Inventory.** The State-Trait Anger Expression Inventory (STAXI; Spielberger, 1988) was developed as a 44-item multi-faceted measurement, designed to assess both the experience and expression of anger. Using self-report, individuals are asked to provide ratings of the degree to which statements apply to them. Possible response ranges from 1 = almost never, to 4 = almost always. Modelled in a fashion similar to Spielberger's (1966) conceptualization on anxiety, the STAXI measures anger on both the state and trait dimensions. While state anger is defined as an acute and temporary state elicited by various aspects of the immediate situation, trait anger (T-Ang) is a more stable predisposition to elevated levels of anger in response to a wider array of

stimuli (Fuqua et al., 1991). Factor analysis of the T-Ang items (Spielberger, Jacobs, Russell, & Crane, 1983) indicated the presence of two factors: angry temperament and angry reaction. The angry temperament facet represents the level to which an individual experiences and expresses anger without provocation, whereas the angry reaction facet represents the tendency to express anger in response to criticism or unfair treatment (Spielberger, 1988). The STAXI captures anger expression by identifying three dimensions: anger-in (AX/IN), anger-out (AX/Out), and anger-control (AX/C). These dimensions of expression capture anger that is considered to be expressed internally by suppressing it, externally towards others or objects, or controlled through various de-escalation techniques, respectively. Example items include: "I have a fiery temper" (T-Ang), "I boil inside, but don't show it" (AX/IN), "I strike out at whatever infuriates me" (AX/Out), and "I keep my cool" (AX/C).

In an attempt to identify the personality correlates of the STAXI facets, Martin and colleagues (1999) examined the role of personality traits initially using the Big Five Inventory (BFI; John, Donahue, & Kentle, 1990) and found that the AX/IN scale was significantly correlated with neuroticism ($r$ = .48), extraversion ($r$ = -.36), A ($r$ = -.36), and conscientiousness ($r$ = -.20). Showing slightly different associations, AX/Out was significantly related to neuroticism ($r$ = .26), agreeableness ($r$ = -.55), and conscientiousness ($r$ = -.24), but was unrelated to extraversion and openness to experience. As part of the same investigation, the NEO-FFI (Costa & McCrae, 1992) was also administered and was found to provide slightly different results. Notably, the AX/IN scores were no longer significantly correlated with agreeableness ($r$ = -.12, *ns*) and the AX/Out was no longer related to conscientiousness ($r$ = -.01, *ns*), but the AX/Out did show a correlation with openness to experience ($r$ = -.16); suggesting that the trait openness to experience is defined differently by the BFI and the NEO-FFI. In relation to this variation, Jones and colleagues' (2011) meta-analysis examining the facets of the BFI found that

only the openness to experience facet "feelings" was related to aggression ($r$ = -.18). Examining the relationship between the Big-5 and trait-anger in a sample ($n$ = 358) of students and individuals related to them (e.g., friends, family) Sanz and colleagues (2010) administered the NEO PI-R and STAXI. Only reporting on trait anger in their analysis, the only significant correlation existed with neuroticism ($r$ = .34). Further, neuroticism remained a robust predictor of trait-anger ($\beta$ = .41) in their subsequent regression analysis.

It should be noted that the STAXI and other prominent scales used throughout the research examining anger and aggression are frequently misinterpreted, contributing to mislabelled results. For example, factor analyses of the State-Trait Anger Expression Inventory (STAXI; Spielberger, 1988) suggests a six factor solution (Forgays et al., 1997; Fuqua et al., 1991), and of the 44 significantly loading items only five address verbal aggression (e.g., "say nasty things"), three allude to either verbal or physical aggression (e.g., "express my anger"), and none are explicitly measuring physical aggression, despite several items addressing "losing one's temper" or being "hotheaded". This is mentioned not as an attempt to criticize the STAXI and its ability to measure anger, but rather to provide argument that the STAXI should not be used as a measure of aggression as some have (Ode et al., 2008; Nickel et al., 2005).

**Aggression Questionnaire.** In their development of the 29-item Aggression Questionnaire (AQ), Buss and Perry (1992) noted that four factors emerged, and interpreted the facets as: Physical Aggression ("If someone hits me, I hit back"), Verbal Aggression ("I often find myself disagreeing with other people"), Anger ("Some of my friends think I'm a hothead"), and Hostility ("I am suspicious of overly friendly strangers"). These four subscales have subsequently been used extensively throughout research examining anger and aggression as defined constructs. Using a 7-point Likert scale individuals provide ratings indicating the degree to which statements are characteristic of them. Possible

response ranges from 1 = extremely unlike me, to 7 = extremely like me. Using the NEO-PI-R (Costa & McCrae, 1992), Sharpe and Desai (2001) examined the personality correlates of the AQ. The total AQ score significantly related to neuroticism ($r$ = .49), extraversion ($r$ = -.20), agreeableness ($r$ = -.54), and conscientiousness ($r$ = -.23), while being unrelated to openness to experience. All facets of the AQ were non-significantly related to the personality trait openness to experience, except for Verbal Aggression ($r$ = .13). Physical Aggression was correlated with neuroticism ($r$ = .26), extraversion ($r$ = -.16), agreeableness ($r$ = -.47), and conscientiousness ($r$ = -.18). Verbal Aggression was correlated with neuroticism ($r$ = .20), openness to experience ($r$ = .13), and agreeableness ($r$ = -.48). Anger was correlated with neuroticism ($r$ = .51), extraversion ($r$ = -.17), agreeableness ($r$ = -.49), and conscientiousness ($r$ = -.24). Finally, Hostility was correlated with neuroticism ($r$ = .61), extraversion ($r$ = -.25), agreeableness ($r$ = -.32), and conscientiousness ($r$ = -.18). Tremblay and Ewart (2005) used the International Personality Item Pool (IPIP; Goldberg, 1999) to establish relationships between personality traits and aggression. Their investigation found that Physical Aggression related to agreeableness ($r$ = -.38) and conscientiousness ($r$ = -.32). The only relationship seen with Verbal Aggression was with agreeableness ($r$ = -.30). Anger was related to emotional stability ($r$ = -.55) and intellect (a factor closely resembling the openness factor of other personality measures; $r$ = -.32). Finally, Hostility was related to extraversion ($r$ = -.30), emotional stability ($r$ = -.44), and intellect ($r$ = -.29). These findings are consistent with Sharpe and Desai's (2001) investigation in that neuroticism is most related to the internal processes of anger and aggression, while agreeableness remained the most robust association with outward expressions of aggression. Using the Revised Interpersonal Adjective Scales- Big Five (IASR-B5; Trapnell & Wiggins, 1990) Gallo and Smith (1998) established a predictive model within an undergraduate sample ($n$ = 274). Regression analysis indicated that the strongest predictor of both Physical Aggression and Verbal Aggression was

agreeableness ($\beta$ = -.35 and $\beta$ = -.31, respectively), while neuroticism was the strongest predictor of both Anger and Hostility ($\beta$ = .46 and $\beta$ = .43, respectively).

**Cook-Medley Hostility Inventory.** One of the earliest examples of a measure of hostility, the Cook-Medley Hostility Inventory (Ho; Cook & Medley, 1954) is a 50-item measurement derived from the Minnesota Multiphasic Personality Inventory (Schiele, Baker, & Hathaway, 1943). Originally designed to measure teachers' abilities to relate to their students, this scale has been shown to predict numerous outcomes, including increased alcohol and tobacco consumption, coronary heart risk, premature death due to non-cardiovascular causes, ineffective coping styles, marital conflict, and general negative affect (Barefoot et al., 1989; Blumenthal, Barefoot, Burg, & Williams, 1987; Smith et al., 1988; Smith, Sanders, & Alexander, 1990). In an exploratory factor analysis, Martin and colleagues (2000) reported that the Ho captures two distinct factors of hostility: antagonism and alienation. Noting the distinction between experiential (cognitive) and expressive (behavioural) hostility (Siegman, 1994), the content of the Ho largely captures the latter (Miller et al., 1996), and has been argued to lack the internal consistency required to adequately make inferences to the cognitive attributes underlying hostility (Contrada & Jussim, 1992). A review of the literature indicates that there are no (to the best of our knowledge) investigations into how the Ho relates to contemporary models of core personality (e.g. Big Five, HEXACO), though it is theoretically assumed to relate to high neuroticism and low agreeableness (Martin et al., 2000).

**Novaco Anger Scale.** There has been relatively little attention paid to establishing how the Novaco Anger Scale (NAS; Novaco, 1994) relates to individual differences such as core personality – no literature was able to be found relating the NAS to core personality traits. The NAS is administered in two parts. Part A consists of 60 items and measures the cognitive (attentional focus, rumination, hostile attitude, suspicion), arousal (intensity,

duration, somantic tension, irritability), and behavioural (impulsive reaction, verbal reaction, physical confrontation, indirect expression) domains. Part B measures the self-report of how angry an individual might become in response to 25 hypothetical situations varying in the nature of provocation (i.e., disrespectful treatment, unfairness/injustice, frustration/interruptions, annoying traits, irritations). The NAS was seen to reliably discriminate between those referred to anger management interventions ($n$ = 58) and non-clinical controls ($n$ = 430; Jones, Thomas-Peter, & Trout, 1999). Baker, van Hasselt, and Sellers (2008) administered both the NAS and the State-Trait Anger Scale (Spielberger, Jacobs, Russell, & Crane, 1983) in a sample of adult offenders ($n$ = 1308). Results indicated that trait anger was significantly correlated with the cognitive ($r$ = .57), arousal ($r$ = .64), and behavioural components ($r$ = .68) of the NAS. Despite a relative lack of investigations using the Novaco Anger Scale (NAS; Novaco, 1994), it may capture a dynamic account of anger. Rather than attempting to capture a broadly define view of anger (e.g. trait anger), the NAS attempts to identify the process underlying the experience of anger.

**Reactive-Proactive Aggression Questionnaire.** Rather than focusing on the variation of outward expressions of aggression (i.e. physical, verbal) the 23-item Reactive-Proactive Aggression Questionnaire (RPQ; Raine et al., 2006) attempts to elucidate the motive (i.e. reactive, proactive/instrumental) behind the aggressive act. Individuals provide self-report ratings indicating how often they have behaved aggressively in either reactive ("Damaged things because you felt mad") or proactive ("Had fights with others to show who was on top") styles. Possible response ranges from 0 = never, to 2 = often.

Using the NEO-PI-R (Costa & McCrae, 1992) personality assessment Miller and colleagues (2012) established correlations between the RPQ and core personality traits. At the domain level correlations with reactive aggression were found with neuroticism ($r$ =

.38), agreeableness ($r$ = -.30), and conscientiousness ($r$ = -.28). Further inspection of the most robust relationship with reactive aggression reveals that all neuroticism-related subfacets positively relate, except for anxiety and self-consciousness. Proactive aggression related to agreeableness ($r$ = -.48) and conscientiousness ($r$ = -.37). More nuanced correlations between proactive aggression and facets of agreeableness suggest that all facets, except trust, are negatively related and represent the strongest associations between personality and proactive aggression. Further regression analysis conducted by Miller et al. (2012) suggests that predictors of reactive aggression include neuroticism ($\beta$ = .25), extraversion ($\beta$ = .20), and agreeableness ($\beta$ = -.23), while predictors of proactive aggression include agreeableness ($\beta$ = -.21) and conscientiousness ($\beta$ = -.11). In short, neuroticism and agreeableness represent the strongest overall correlations, and predictors of an aggressive response. Moreover, agreeableness significantly predicts both reactive aggression and proactive aggression, while neuroticism only predicts reactive aggression.

**Behavioral Anger Response Questionnaire.** Focusing specifically on the expression of anger, Linden and colleagues (2003) felt that the dichotomous ratings of anger-in vs. anger-out were too course, and so developed the 37-item self-report Behavioral Anger Response Questionnaire (BARQ). Using a Likert scale, individuals are asked to provide ratings indicating the degree to which they agree that statements apply to them, from 1 = not true to 3 = often true. Exploratory factor analysis (Linden et al., 2003) suggested six expression related factors: (1) direct anger-out (outward displays of aggression), (2) assertion (direct, yet non-aggressive, interaction with the provocation agent), (3) support-seeking (seeking a person external to the event for emotional support) , (4) diffusion (direct, yet passive and non-violent, coping; e.g., exercise), (5) avoidance (forgetting or ignoring anger), and (6) rumination (cognitively replaying the provocation, lacking outward expressions of anger).

Using the NEO-FFI (Costa & McCrae, 1992) metric of personality and a sample of both community and student participants ($n$ = 400), Hogan (1998) identified correlations between the BARQ and the five-factor model of personality. Direct anger-out was most correlated with agreeableness ($r$ = -.51) and conscientiousness ($r$ = -.21). Assertion was most related to conscientiousness ($r$ = .20), extraversion ($r$ = .25), neuroticism ($r$ = -.20), and openness to experience ($r$ = .21). Diffusion only related to neuroticism ($r$ = .21). Rumination was related to agreeableness ($r$ = -.29), conscientiousness ($r$ = -.23), and neuroticism ($r$ = .47). Finally, avoidance and support-seeking had no significant correlations with any of the Big-five personality factors. Linden and colleagues' (2003) investigation examining a student sample ($n$ = 232) yielded similar results and trends. Direct anger-out was related to agreeableness ($r$ = -.45) and conscientiousness ($r$ = -.17). Assertion was related to conscientiousness ($r$ = -.23), openness to experience ($r$ = .31), and extraversion ($r$ = .24). Diffusion was only related to neuroticism ($r$ = .27). Rumination was related to agreeableness ($r$ = -.24) and neuroticism ($r$ = .48). Finally, consistent with Hogan (1996), avoidance and support-seeking had no significant correlations with core personality traits. The most robust correlation with outward expressions was with agreeableness, while neuroticism shared its most robust correlation with the cognitive process of rumination.

**Displaced Aggression Questionnaire.** Rather than focusing on aspects of direct aggression (i.e. aggression directed at the provoking agent), Denson and colleagues (2006) developed the Displaced Aggression Questionnaire (DAQ) in an attempt to capture aspects of displaced aggression (i.e. aggressing against an innocent or unrelated target following a provocation). Individuals are asked to provide ratings on a Likert scale indicating the degree to which statements are characteristic of them. Possible response ranges from 1 = extremely uncharacteristic of me, to 7 = extremely characteristic of me. Confirmatory factor analysis of the 31-item, self-report DAQ (Denson, Pedersen, & Miller, 2006)

indicated the presence of three factors, interpreted to represent: angry rumination (e.g. “I keep thinking about events that angered me for a long time”), revenge planning (e.g. “If someone harms me, I am not at peace until I can retaliate”), and displaced aggression (e.g. “When feeling bad I take it out on others”).

Using the DAQ (Denson et al., 2006) to examine displaced aggression and vengefulness, respectively, Lee and Ashton (2012) established correlations between these outcome variables and the HEXACO (Ashton & Lee, 2007) model of personality within a student sample ($n$ = 198). Displaced aggression showed significant correlations with honesty-humility ($r$ = -.26), emotionality ($r$ = .23), agreeableness ($r$ = -.42), and openness to experience ($r$ = -.20). Vengefulness related to honesty-humility ($r$ = -.40), agreeableness ($r$ = -.49), and conscientiousness ($r$ = -.32). Immediate Reaction correlated with extraversion ($r$ = .14) and agreeableness ($r$ = -.29). Finally, Calculated Reason related to honesty-humility ($r$ = -.37), agreeableness ($r$ = -.32), and conscientiousness ($r$ = -.19). Consistent with Ashton and Lee’s prediction, agreeableness influenced both immediate angry reactions and premeditated reactions directed towards the offending agent, while honesty-humility only influenced the latter.

**Consistent themes between measures**

The preceding review reveals two important details related to this thesis’ interest in the individual differences related to anger. Firstly, the constructs of anger, hostility, and aggression are highly correlated, yet independent constructs, each containing multiple facets. Secondly, dependent on which of any of the facets is under investigation, predictors such as core personality traits relate differentially. Broadly speaking, however, the affective and cognitive components most related to anger relate most heavily with neuroticism or emotional stability, while the outward expression or behavioural

components of anger – at least as these expressions relate to others – are most strongly related to agreeableness.

## Theories on the aetiology of anger, hostility, and aggression

Next, this thesis will briefly review some of the more prominent theories regarding the aetiology of anger, hostility, and aggression. While no individual theory presents an all-encompassing explanation, each has strengths that help form the foundations for more general models of the pathways towards anger, hostility, and aggression.

**Frustration-aggression theory.** As an early theory on the cause of anger, the frustration-aggression theory (Dollard, Doob, Miller, Mowrer, & Sears, 1939; Miller, 1941) held that frustration can cause both aggressive and non-aggressive responding, but that aggression is always preceded by an increase in an individual's frustration. Without making any assertion as to whether aggression was an innate or socially-learned phenomenon, Dollard and colleagues (1939) built their theory upon "commonsense", clinical, and experimental observations, believing that particular individuals are more prone to responding aggressively to a frustrating event. The frustration-aggression theory received considerable attention, and shaped numerous investigations into the causes and consequences of aggression (e.g. Berkowitz, 1958, 1962; Buss, 1961). The frustration-aggression theory has been criticized for not devoting enough attention to how any individual differences influence the likelihood of aggressive responding (Berkowitz, 1989).

**Social learning theory.** Social learning theory, as a broad concept, is based upon the operant conditioning of behaviour (Bandura & Walters, 1963). As it relates to aggression, the social learning theory identifies four basic processes central to the development of aggression (Bandura, 1973): 1) attention is paid to another individual acting aggressively,

2) retention allows the observer to remember others' aggressive behaviour, 3) motivation to replicate the observed behaviour (e.g. desire to replicate the perceived favourable outcome observed in the original aggressive act), and 4) reproduction of the behaviour if the observer is confident that they can imitate the observed behaviour. Similar to the frustration-aggression theory, the social learning theory of aggression largely fails to address the role of individual differences or dispositional traits on the pathway towards aggression.

**Excitation transfer theory.** The excitation transfer theory of aggression maintains that arousal caused by one stimulus will potentiate the arousal caused by a temporally close secondary stimulus, and that this transfer is not limited to a single emotion (Zillmann, Johnson, & Day, 1974). Zillmann and colleagues noted that, following a task involving physical exertion, participants with the lowest levels of baseline fitness demonstrated the strongest excitation transfer (i.e. were more aggressive), compared to their more physically fit counterparts. Excitation transfer requires three conditions to be present (Cantor, Zillmann, & Bryant, 1975): 1) the secondary stimulus must occur before the original stimulus' excitation is extinguished, 2) the individual must misattribute all excitation to the secondary stimulus, and 3) the individual must not have reached the relevant excitatory threshold before experiencing the secondary stimulus. In other words, excitation transfer occurs if two independent and physiologically arousing events occur within a close timeframe of each other, and despite the original stimulus' failure to evoke anger, the cumulative arousal (e.g. anger) experienced by the individual is attributed solely to the latter event and is at a level that the second event would have been unable to solely evoke.

**Script theory.** In an attempt to explain the correlation between violent media exposure and criminal behaviour (Huesmann & Eron, 1986), Huesmann developed the script theory of aggression (Huesmann, 1986). In short, Huesmann asserts that aggressive behaviour is the result of the learning of aggressive scripts. Scripts represent a set of rehearsed concepts

involving causal links, goals, and action plans (Huesmann, 1986). Simply put, individuals (often children) watch others use anger or aggression in response to events in an effort to accomplish personal goals, causing the individual to form a cognitive association between anger or aggression and the achievement of personal goals – the individual then goes on to use anger or aggression as a means to accomplish their personal goals. The script theory emphasizes the role that exposure to violent media has on children developing learned scripts about when aggressive or violent behaviour is considered acceptable. This cumulative learning process, throughout childhood, builds stable and long lasting schemas for aggressive behaviour. Importantly, Huesmann (1986) acknowledges the presence of moderating variables (e.g. parental influence, social popularity) that may dampen the association between exposure to violent media and future aggressive behaviour; a consideration that has been largely overlooked or ignored by subsequent investigations into media's influence on aggressive behaviour (e.g. Anderson, 2004; Anderson & Bushman, 2001).

**Socioecological theory.** In an attempt to gain some insight into the factors influencing the likelihood of aggression – particularly, aggression against women – Heise (1998) developed a socioecological theory of violence. Building upon correlational and anecdotal observations, the socioecological theory encompasses multiple levels: the personal (e.g. witnessing violence as a child), microsystem (e.g. use of alcohol), exosystem (e.g. socioeconomic status), and macrosystem (e.g. rigid gender roles) levels. Heise suggested that the socioecological framework be applied to future empirical investigations, guiding the hypothesis. Representing one of the first attempts to bring together the multiple influential pathways contributing to an angry, hostile, or aggressive outcome, the socioecological theory considers how multiple factors, within an individual's life, may interact to produce the relevant outcomes.

## More recent theories

**Behaviour genetics**. Evidence indicates that anger and aggressive behaviour are, at least in part, heritable. Some of the earliest evidence related to the heritability of anger and aggressive was conducted using twin study designs. For example, in an examination of 500 healthy monozygotic and dizygotic twin pairs, raised together or apart, indicated a significant genetic influence related to aggression and "impulsive irritability", while shared environmental influences were statistically insignificant (Coccaro, Bergeman, & McClearn, 1993). Similarly, Rushton and colleagues (1986) examined 573 twin pairs, raised together, and found that genetic and unique-environmental factors were significant influences influencing aggressive behaviour, while shared-environmental factors did not play a significant role in determining the relevant outcome.

Building upon the early twin-design studies described above, more recent investigations have identified serotonin as a likely candidate influencing the development of aggression – with reduced serotonergic activity being robustly associated with increases in aggression (e.g. Brown et al., 1979; Brown et al., 1982; Kruesi et al., 1990). Manuck and colleagues (1999) observed that self-reported aggressive behaviour was most prevalent in individuals ($n$ = 251) with a genetic predisposition – i.e. intronic polymorphism of the gene coding for tryptophan hydroxylase – that reduced their ability to biosynthesize serotonin, compared to those without the predisposition. Using a cohort of 566 participants (203 individuals who had attempted suicide and 363 controls), Giegling and colleagues (2006) found that those with a single-nucleotide polymorphism negatively affecting their serotonin receptors self-reported increased levels of anger and aggressive behaviour. More recently, responding to concerns that false positive findings have plagued candidate gene studies (Munafo & Flint, 2011, Ficks and Waldman (2014) reported on a meta-analysis of serotonin and monoamine oxidase candidate gene studies. They, through use of a meta-analysis, noted that antisocial behaviour (e.g. aggression, criminality) was associated with

variations in the serotonin transporter gene (i.e. 5HTTLPR) and a gene (i.e. MAOA-uVNTR) influencing how neurotransmitters, including serotonin, are metabolized.

**Recalibrational theory**. In an effort to explain the evolved function of anger and aggression, Sell (2005; 2011) developed the recalibrational theory of anger. In his recalibrational theory, Sell proposes that anger serves as a regulatory neurocognitive program designed to influence bargaining and conflicts in favour of the angry individual. In other words, the evolved function of anger is to incentivize the target of one's anger to place more welfare or concern in the angry individual's interest.

Similar to other evolved processes that are designed to negotiate interactions in a fitness promoting fashion – e.g. kin-directed altruism (Hamilton, 1964), disgust (Tybur, Lieberman, Kurzban, & DeScioli, 2013) – the recalibrational theory of anger has three primary stages (Sell, Tooby, & Cosmides, 2009). Firstly, the individual interprets the probable effect another's action may have on the individual's own welfare. Secondly, the individual interprets the probable effect that the other's action may have on the other's welfare. And finally, the individual makes use of a weighting function that establishes the importance of the other's welfare in comparison to the individual's own welfare. If the individual believes that, 1) the other's action negatively impacts their own welfare, 2) this impact places additional welfare in the other's interest, and 3) the individual believes that they are deserving of greater welfare than the other, then the individual will likely become angry.

An important aspect of the recalibrational theory's overall process, and what forms the foundation of the weighting process described above, is the formidability of the individual compared to the other. More formidable individuals are capable of inflicting greater costs or penalties (e.g. physical harm, ostracisation) on others and are therefore worthy of increased attention being paid to their welfare, lest they attempt to recalibrate the

situation in their favour and cause harm in the process. In a series of experiments, Sell and colleagues (2009) found evidence that formidability is reflected, in part, by physical strength (i.e. potential cost infliction) in men and by attractiveness (i.e. potential benefit conferral) in women, and that individuals higher in their respective formidability quotient self-report increased personal anger and both personal and political (e.g. use of war to solve conflict) aggression.

### Using theories to develop broader conceptualizations of anger

Each of the theories described above attempts to identify the causal factors of anger, hostility and aggression. However, what they lack individually – and what the socioecological theory attempts to outline – is an overarching model that incorporates the supporting evidence related to each trait. Fortunately, more recent efforts (e.g. Anderson & Bushman, 2002; Finkel, 2013; Wilkowski & Robinson, 2010) have begun to address this need, and help form a more comprehensive understanding of the multiple influential factors that increase the likelihood of an angry, hostile, or aggressive outcome.

## Models of anger, hostility, and aggression

The measures used to capture the affective, cognitive, and behavioural components of anger have helped identify some general processes forming the framework for models. Here, several of the more prominent models will be discussed. While this review is by no means exhaustive, the models presented here describe what is currently understood about the pathways towards anger, hostility, and aggression.

**The General Aggression Model.** The General Aggression Model (GAM; Anderson & Bushman, 2002; DeWall et al., 2011) is a social-cognitive model and attempts to provide

an overarching theory to the propensity to aggress that previous mini-theories (e.g. frustration-aggression, socioecological, social-learning, script, excitation transfer) fail to construct or define (DeWall et al., 2011). Following innate predispositions towards anger and aggression, the model identifies several distinct stages that may contribute to a feedback loop, creating an augmenting cycle of aggression: (1) personal and situational inputs, (2) present internal states, and (3) outcomes of appraisal and the decision-making processes.

Personal factors (i.e., traits, sex, beliefs, attitudes, values, long-term goals, scripts) are dispositions considered to be stable over time and across circumstances. This sum of schemata, scripts, and knowledge structures (Anderson & Bushman, 2002) influences the types of situations an individual will seek out, those which they will attract, and how they will interpret and respond to such events.

The internal states of most interest to the model are cognition, affect, and arousal (Anderson & Bushman, 2002). Collectively, the internal states simultaneously receive input, and may serve to reinforce each other. Aggression prone cognition (i.e. hostile thoughts, scripts) begins with readily accessible aggressive concepts in memory (hostile thoughts), creating primers sensitive enough to be triggered by commonly assumed innocuous environmental effects such as media exposure. The cognitive process then follows pre-existing aggressive scripts. Affect (i.e. mood and emotion, expressive motor responses) is defined within the model as the experience of anger and general hostility. Finally, the internal state of arousal consists of both psychological and physiological arousal, which may or may not coincide, and is argued to influence the likelihood to aggress in three ways. First, irrelevant or unrelated arousal, such as physical exercise, increases aggressive responding. Second, these irrelevant arousals can be mislabelled as anger, moderating the aggressive response, and creating a feedback loop for more arousal

to occur. Finally, the GAM theorizes that high levels of arousal are aversive states and as such are capable of stimulating aggression in the same manner as other aversive (e.g. painful) stimuli (Anderson & Bushman, 2002). These internal states provide the basis of the appraisal and decision processes, resulting in outcomes.

The appraisal factor is based upon research on spontaneous inferences and on explanation and attribution bias and is fractionated into immediate appraisal and reappraisal domains, determining the final action of the episode (Anderson & Bushman, 2002). Appraisals or reappraisals of attribution form a link between perception and emotion (Smith & Ellsworth, 1987). Smith and Lazarus (1993) identified that appraisals occur at two levels: firstly at an individual component level, and secondly at a molar level comprised of the individual components. The individual components, identified by Smith and Lazarus, relate to a situation's motivational relevance (i.e. relevance of the situation to the individual's goals) and motivational congruence (i.e. is the event consistent or inconsistent with the individual's goals). The secondary molar appraisals relate to accountability (positive or negative) within the situation, and the individual's coping potential – i.e. the individual's ability to change the situation towards one's goals (i.e. problem-focused coping) or by adapting to the situation (i.e. emotion-focused coping) should it remain incongruent with overall goals.

The input systems mentioned thus far shape the automatic inference undergoing appraisal. The outcome of the immediate appraisal is dependent upon available resources (e.g. time, cognitive capacity). If the outcome is important, yet unsatisfying, the more effortful process of reappraisal occurs. Otherwise, impulsive action occurs and the propensity for an aggressive response is based upon the content of input systems. Reappraisal is the search for an alternative solution and may endure numerous cycles as alternatives are reviewed and discarded. "At some point the recycling process ceases" (Anderson & Bushman, 2002) and formulated action occurs. Behavioural action is then fed

into the social encounter, which will in turn be incorporated and looped back into all input modifiers.

More recent revisions (see Figure 1.1) of the GAM by DeWall and colleagues (2011) include the lower-order inputs of biological and environmental modifiers which construct personality; a more comprehensive model than the original (Anderson & Bushman, 2002) which began without explicitly addressing a biological and environmental interaction or input. Nonetheless, while the newer model of the GAM mentions biological modifiers it fails to expand upon this factor; referring instead to the original model's (Anderson & Bushman, 2002) definition which lacks this category altogether.

Several challenges exist related to this model. First, this model's component of affect and hostility differs from Buss and Perry (1992) who assert that hostility, while correlated, more importantly measures independent of anger and is thus identified as a cognitive process. Secondly, the notion that affect and cognition receive input simultaneously discounts the notion of a temporal difference between mood or emotion and a reappraisal process, or that one might have a moderating influence over the other. Third, the grouping of modifiers from varied domain-levels is too broadly inclusive. For example, modifiers such as personality related factors (e.g. hostile attribution bias, self-esteem) and beliefs (e.g. self and outcome efficacy) are clustered with the purely biological factor of sex. Consequently, this inflated category ignores, or fails to address, the precursory role biology plays in the development and expression of larger constructs such as personality and schemas. Within the model, situational factors (e.g. aggressive cues, provocation, frustration, pain and discomfort, drugs, incentives) are salient influences, acute to the context, which moderate subsequent cognition, affect, and arousal. Similarly, a drawback to this component is its broad encompassing of modifiers. Aggressive cues (which perceptually fluctuate with state and trait personal factors) are grouped with the physiological arousal factor of pain. This overly inclusive category, by grouping together

biological and cognitive factors, fails to address the interactive effects lower-order constructs (e.g. biological predispositions) might play on the influence of higher-order components (e.g. psychopathology) that relate to anger and aggression.

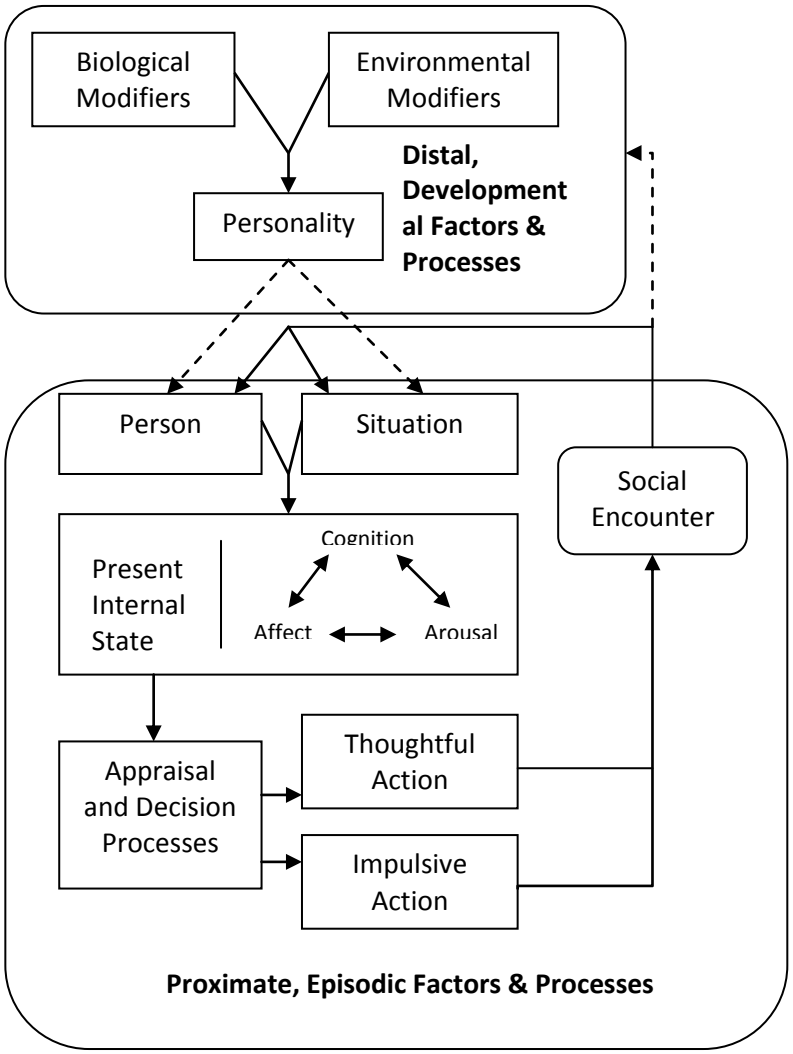


*Figure 1.1.* The General Aggression Model (adapted from DeWall et al., 2011).

**The Integrative Cognitive Model.** Central to the Integrative Cognitive Model (ICM; Wilkowski & Robinson, 2010) are three cognitive processes (see Figure 1.2) mutually contributing to the expressions of trait anger and reactive aggression. These processes are: (1) an automatic and involuntary hostile attribution bias, (2) rumination, and (3) effortful

control. The ICM model utilizes these processes to account for individual differences in anger and reactive aggression. Despite explicitly differentiating between state and trait anger and between reactive and proactive aggression, the authors' review of this model interchangeably refers to both the more nuanced and the broad categories (Wilkowski & Robinson, 2010). Therefore, this current review will refer to the specific concept or construct (i.e. anger, trait anger, state anger, aggression, proactive aggression, reactive aggression) being explicitly addressed by Wilkowski and Robinson (2010).

The cognitive processes principal to the ICM moderate the relationship between the hostile stimuli and the affective or behavioural outcome expressions (i.e. anger, aggression). Further, the processes function independently, either exacerbating or suppressing outcome behaviours. The first process ("Hostile Interpretation") addresses the tendency of the individual to interpret a situation, possibly an ambiguous or accidental one, as a hostile event. This is considered an example of social inference; an automatic and unconscious process responsible for the frequency of affective anger. The second process ("Ruminative Attention") directs the individual's attention toward memories of previous events interpreted in a hostile manner, reinforcing the earlier hostile attribution bias, thereby amplifying and prolonging affective anger which in turn increases the likelihood of reactive aggression. The final process ("Effortful Control") suppresses emerging hostility, anger, and reactive aggression. Finally the authors propose that an individual's use and effective implementation of this effortful control process predicts levels of trait anger.

Wilkowski and Robinson (2010) assert three key points of the ICM: First, hostile biases are not only involved in the elicitation of anger, their saliency acts as a crucial predictor of angry affect. Second, hostile biases may also serve to increase aggressive responding, to the extent of anger as a mediator in this effect. Third, hostile attributions are automatic. The ICM asserts that hostile ruminations intensify the effects of negative stimuli on state anger, trait anger, reactive aggression, retaliatory aggression, and displaced

aggression (Wilkowski & Robinson, 2010). This selective attention process highlights the perceived negative events from previous encounters, while overlooking positive or ambiguous events, thereby reinforcing hostile cognitions and affects following stimuli exposure. The authors note that the ICM does not exclude the possibility of attentional biases that may be occurring prior to hostility related stimuli processing.

Effortful control is the finite resource employed to override or suppress tendencies contrary to the individual's goals and is considered to be temporally and contextually stable. Relating this trait to effective coping styles, Wilkowski and Robinson (2010) note its inverse relationship with self-reported and observer-reported levels of trait anger, reactive aggression, and other behavioural expressions of anger. The ICM contends that low trait anger individuals enlist this process spontaneously when hostile cognitions are detected. Further, all individuals, regardless of trait anger levels, are only able to effectively engage this process when sufficient time is allowed for the access of control resources.

In short, the ICM submits that automatic hostile interpretations are the primary contributors to the frequency of anger arousal, but they do not sufficiently address behavioural reactivity to situations. Rumination is believed to bolster and intensify affective anger, but also falls short of reliably predicting aggression. The ICM asserts that the sum of these two processes construct the propensity to aggress, which is then available for influence by available effortful control processes. This final process, being the highest order construct within model, requires the most available resources for implementation and may effectively down-regulate aggression or moderate previous processes' input towards anger.

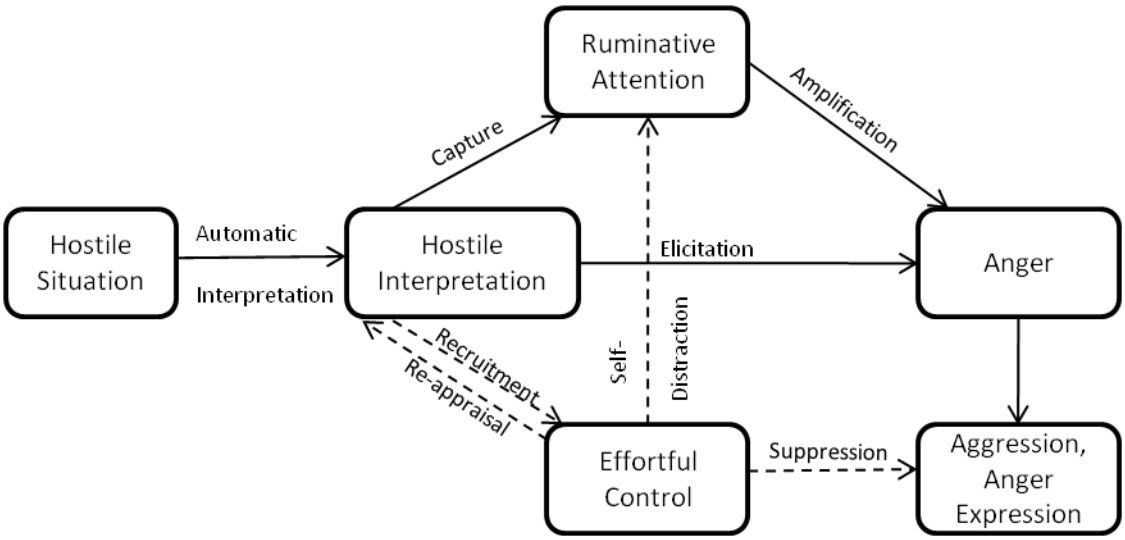


*Figure 1.2.* The Integrative Cognitive Model (adapted from Wilkowski & Robinson, 2010).

**The I$^3$ Model.** The I$^3$ (pronounced "I-cubed") model is designed as a metatheory; a general purpose framework (see Figure 1.3) with which to study behaviour (Finkel, 2013). While theories enable the generation of falsifiable hypotheses, metatheories lack any pretense of their assumptions being falsifiable within any given study and unite assumptions that when viewed together advance the formation of theories. More simply, metatheories facilitate the development of theories (Finkel, 2013). Within the I$^3$ model the central predictor of anger or aggression is the presence or strength of a behavioural proclivity, or propensity to implement angry affect or aggressive behaviour. This proclivity can stem from "hot" affective processes or "cool" cognitive processes, or a combination of the two and result in the behavioural expression unless inhibitory effects override it (Finkel, 2013). The I$^3$ model of anger suggests all behavioural expressions are the sum of three processes: instigation, impellance, and inhibition. Simply put, the highest likelihood and intensity of aggression occurs while instigation and impellance are strong and inhibition is weak.

Instigation is the effect produced by exposure to a particular stimulus in a particular context that encourages behaviour associated to the stimulus-directed behavioural options unique to the individual. The concept of Instigation refers to what a particular environmental or situational stimulus provides an individual. Within Instigation, affordance refers to the stimulus's characteristics available for assimilation which are made available to any comparable individual, to which the potential responses are normalized to the situation. Separate to this concept is Impellance, which is what the individual uniquely brings to the situation (e.g. scripts, goals and motivations, traits). Impellance is composed of the state and trait factors that elevate the likelihood or intensity of afforded behaviours when a stimulus is encountered in contextual situations. Impellance influences the psychological state of the individual experiencing instigation either immediately or after the fact (i.e. rumination). While instigation invokes the cultural and social norms attributed to a stimulus, impellance refers to influences that are unrelated to the target stimuli, and are instead traits specific to the individual. Inhibition refers to the state or trait factors that increase the likelihood or intensity of suppressing the effects of instigation and impellance on an outcome. Readily available executive and self control resources allows for the increased suppression of processes operating in conflict to the individual's goals. These three functions operate orthogonally within the model and are thus able to vary independently. An essential component of the $I^3$ model is the interchangeable and interactive nature of the three core processes (Finkel, 2013).

This model differs from more commonly asserted dual-process models in that these previous models emphasise one system of automatic and involuntary response, and another more effortful system allocating attention to activities that demand it. Central to these dual-process models is that the outcome action is the result of only one or the other process. Due to the orthogonal nature of $I^3$ facets, they cross-cut and can function in either system,

creating a 3 × 2 factorial structure (Finkel, 2013) that allows for theories related to conditional and interactive effects.

Taken together, the $I^3$ model asserts three essential principles: (1) all behavioural expressions are produced from main and interactive effects involving instigation, impellance, and inhibition, (2) the associations of these main and interactive effects of instigation and impellance are mediated by the proclivity towards particular behaviour, and (3) inhibition moderates the resulting trajectory to determine expression of behaviour (Finkel, 2013). The overall model forms a complex set of 18 potential effects, many of which are mediated, moderated, or both. As such, this model presents a unique framework with which to conceptualize the likelihood of anger.

To utilize this potentially perplexing framework, Finkel (2013) suggests a three step approach to investigating predictors of aggression. First, hypotheses must be developed at the process (i.e. instigation, impellance, inhibition) level. Specifically, how do these process level effects influence behaviour? Second, constructs must be identified to represent both the processes hypothesized to relate to the outcome of aggression in the relevant context and the behavioural proclivity. For example, an individual might be more prone to become angry when encountering a more salient rather than a benign stimulus (instigation), when they are more antagonistic rather than agreeable (impellance), and when their self-regulatory (inhibition) controls are depleted rather than readily available. Third, each construct must be operationalized. For example, an investigator might operationalize the instigation by exposing participants to either aversive or neutral stimuli. The impellance might be operationalized by the participant's subjective reporting of state and trait characteristics. The inhibition might be operationalized by temporarily exhausting executive control resources.

This meta-theoretical model provides a unique and valuable framework in which to develop, as the author intends, more nuanced theories investigating the interactive effects related to anger and aggression. Moreover, the 18 potential effects this model encapsulates allow for increasingly complex interactions (e.g. moderated-moderator, moderated-mediator, mediated-mediator) to be formulated.

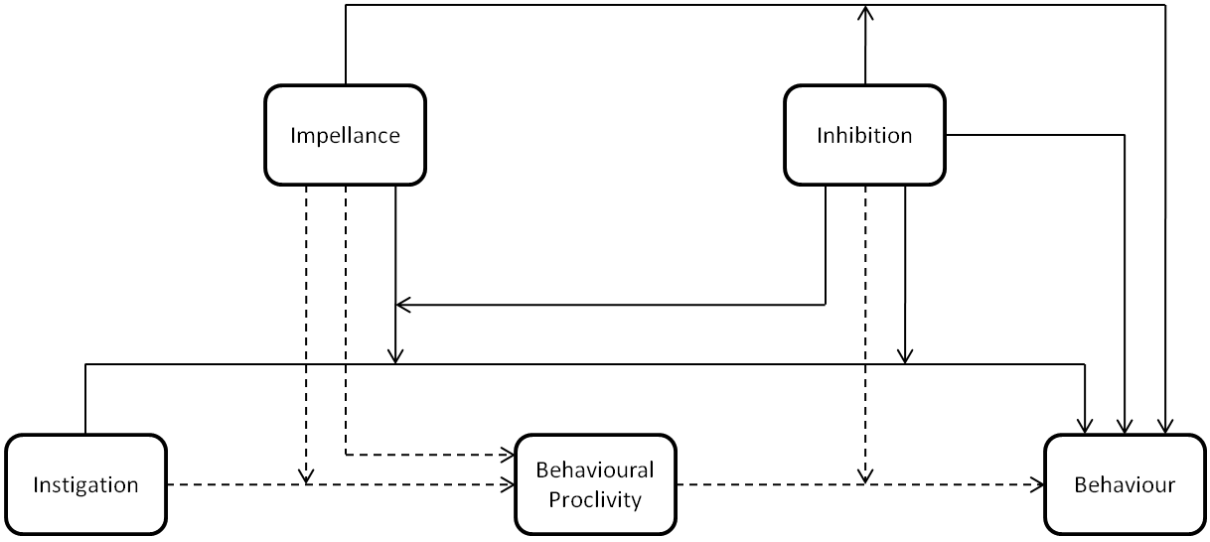


*Figure 1.3.* The $I^3$ Model (adapted from Finkel, 2013).

**Overlap between models**

The models reviewed here have several components that are similar and overlap in how they theoretically function. Prior to a potential transgression or instigation, all models acknowledge a predisposition towards anger and aggression. That is to say each model identifies an innate tendency towards anger and aggression that defines available options for the individual, following a transgression. The GAM and $I^3$ model both discuss how personality might influence a proclivity or pre-disposition toward anger and aggression, and thereby subsequent processes detailed in the respective models. The ICM model does

not explicitly describe personality within the model, but contains several components that have been associated elsewhere with personality traits – e.g. neuroticism's association with hostile interpretations. To this end, the ICM presents a superior model with which to investigate and apply to main and interactive effects of personality, compared to the GAM which has broadly inclusive elements confining personality traits to a fixed location.

Each model also contains an inhibitory component which exerts an effect on the overall pathway to anger and aggression. This effortful control process's proximal role is depicted best by the $I^3$ model, which places it as a potential moderator or mediator at any of the other principal components. All models agree that an inhibitory process will engage if (a) resources are plentiful enough, (b) enough time is allowed for the review process, and (c) the impending outcome conflicts with the individual's goals. This overall process is considered temporally and contextually stable. Once conditions are met and the process is recruited, through a looping system of reappraisals this effortful control process minimizes or distracts ruminating attention or suppresses behavioural expression (ICM), moderates/mediates the effects of impellance and instigation ($I^3$), or results in thoughtful action entered into the social encounter (GAM).

The effect of hostility is depicted within each of the models. More specifically, the models observe an effect of existing scripts or schemas, which bias an individual's perception of an event. Finally, all models agree that the resulting outcome action can form a feedback loop, increasing the tendency to anger and aggress. These overlapping factors identify a rich theoretical foundation for which to base future work on. While the main effects of personality traits on each of these overlap areas have for the most part been established, very few studies have investigated, from a systems level approach, the unique interactive effects between traits as observed through the operationalized components within the models.

In summary, the models attempting to define the pathway to anger and aggression have been built upon a substantial body of knowledge operationalizing and measuring the facets related to anger. These models have identified and agree upon several components: (1) an innate predisposition to respond in a particular style, to a particular stimulus, (2) a pre-existing cognitive script that biases the event's perception, potentially exacerbating affective arousal or behavioural response, and (3) an effortful control or inhibitory system that suppresses affective arousal, beliefs, or behaviours that are contrary to the individual's goals.

## A gray area: How variations in cortical structure and function relate to anger

Recognizing that affective states serve a crucial function in determining how the brain generates behaviour and that animals, other than human, "probably have internally experienced feelings", Panksepp (1998, p. 4) investigated the physiological roots of affective states using animal models focusing on the subcortical systems homologous in all mammals. Through the use of animal models, Panksepp identified six basic affective tendencies (i.e. play, seek, care, fear, anger, and sadness) which were later shown to strongly relate to students' ($n$ = 171) scores in a five-factor model of personality (Davis, Panksepp, & Normansell, 2003). Focusing on the system related to anger, Davis and colleagues report significant correlations with (low) emotional stability ($r$ = -.65), (low) agreeableness ($r$ = -.48), and (low) conscientiousness ($r$ = -.30) – results that largely mirror findings describing the relationship between anger and core personality traits (see above). Interestingly, Davis and colleagues also conducted a factor analysis, and found that of the core affective tendencies identified above, only anger was seen to cross load onto personality factors: (low) emotional stability (loading = .68) and agreeableness (loading = -.53).

Simply put, Panksepp (1998, p. 20) presents evidence for a dual process model of personality, with tendencies emerging from the interaction between the ventral hypothalamic-limbic circuit ("old-mammalian") and the dorsal thalamic-neocortical ("neomammalian") regions of the brain. Using localized brain stimulation and lesion studies, Panksepp notes the interplay between areas associated with general arousal – i.e. the periaqueductal gray, hypothalamus, amygdala – and the regions responsible for inhibitory control of cognitive processes – i.e. medial and lateral frontal cortices. So that an understanding may be drawn between these regions and the experience of anger, I will review some of the key findings related to how each of these areas influence the experience of anger.

**Periaqueductal gray.** The periaqueductal gray (PAG) is present across vertebrate species (Fiebig, 1988; Kittleberger et al., 2006) and is involved in physiological arousal related to numerous processes (e.g. pain, anxiety, reproductive behaviour; Behbehani, 1995). The PAG projects to the thalamus, hypothalamus, brainstem, and spinal cord (Mantyh, 1983) and receives projections from the prefrontal cortex, insular cortex, and amygdala (Mantyh, 1982). As it relates to this current work, meta-analysis of over 250 empirical articles indicated that volumetric changes to the PAG related to significant changes to emotional states (Linnman et al., 2012). Animal models have consistently demonstrated the PAG's role in "defensive rage" behaviour (e.g. biting without warning; Fanselow, 1994; Panksepp, 1998, p. 196), while deep-brain stimulation of this region in adults with intractable pain ($n$ = 15) causes the elicitation of salient emotions (Nashold et al., 1969). This is to say that the PAG is proximal to the experience of affective arousal, including anger, and that activation of or alterations to the PAG can result in an aversive affect (i.e. anger) and aggressive behaviour. However, due to its subcortical location, imaging of this region can be somewhat challenging compared to more cortical areas; although evidence

has been found for anger-related variation in activation within this region (Damasio et al., 2000; Satpute et al., 2013).

**Hypothalamus.** The hypothalamus receives projections from the PAG, and taken together these regions modulate defensive rage (e.g. biting without warning) – behaviour considered to be analogous to affective anger by Panksepp (1998) – in both cats and rats undergoing brain stimulation (Siegal et al., 1999). In the same investigation, Siegal and colleagues report that this region was also seen to also to be involved in initiating a freeze response, suggesting that the hypothalamus is involved in a broader threat-detection system. The visceromotor nuclei of the hypothalamus received projections from the ventromedial regions of the frontal cortex suggesting that this region is involved in the activation of the peripheral autonomic arousal associated with anger (Öngür & Price, 2000). Although anger-related activity within the hypothalamic region has been found across several studies (Denson et al., 2009; Fabiansson et al., 2012; Kimbrell et al., 1999; Pawliczek et al., 2013), it is worth noting that evidence from a healthy adult population ($n$ = 27) suggests that it isn't the valence of the stimuli that evokes activation, but rather the social or interpersonal content of the stimuli (Moll et al., 2012). Moll and colleagues found that it was a contrast of affiliative vs. non-affiliative stimuli that correlated with the greatest change in activation, rather than the contrast between positively vs. negatively valenced items.

**Amygdala.** One of the most consistent findings across the anger-related research is the involvement of the amygdala. A region comprised of several subnuclei, identified by variations in architecture (Brockhaus, 1939, 1940), this region has extensive connections with both cortical and subcortical regions (Sah et al., 2003) and has been associated with a variety of affective and cognitive functions such as defensive response, emotional discrimination, and learning and memory (Ledoux, 2000, pp 289-310; Phelps, 2004). Over one century ago, Brown and Schafer (1888) reported a taming effect, following excision of

this region, in monkeys. Lesions to the human amygdala can result in hypoemotionality and decreased aggression (Aggleton, 1993), and disrupts Pavlovian fear conditioning (LaBar et al., 1995). Empirical evidence suggests that while increased activation within the amygdala is associated with anger (Alia-Klein et al., 2009; Fabiansson et al., 2012; Pawliczek et al., 2013), decreased gray matter within this region is correlated with higher trait anger in a healthy adult sample ($n$ = 47; Reuter et al., 2009), and aggression and psychopathic features in a longitudinal sample of men with various histories of violence ($n$ = 56; Pardini et al., 2014).

**Medial and lateral frontal cortices.** The medial and lateral frontal cortices are broadly defined, containing several distinct structures, and are considered a convergence zone for projections from the limbic and heteromodal association areas (Elliot, Dolan, & Frith, 2000). Crucial to the top-down modulation of bottom-up processes (Frith & Dolan, 1997), these regions possess several distinct and direct projections towards the limbic structures described above (Koechlin et al., 1999; McDonald, Mascagni, & Guo, 1996) and are involved in numerous executive control functions and task management and planning (Fuster, 2001; Luria, 1969, p. 725), including both emotional and behavioural inhibition (Konishi et al., 1999). Because damage to the medial and lateral frontal cortices relates to increases in anger (Anderson et al., 1999; Grafman et al., 1996), and activation in these regions correlates with concurrent decreased activity in the limbic system (Hariri et al., 2000; Hariri et al., 2003), it is thought that these regions primarily relate to anger in that they inhibit or regulate the experience and expression of anger.

## Regions involved in cognitive control of emotions

Although not directly relate to anger per, emotion regulation systems are important components, as outlined in the $I^3$ model (Finkel, 2013). In a comprehensive review of the cognitive control of emotions, Ochsner and colleagues (2012) identify three regulatory

cognitive processes: attentional deployment, cognitive change, and response modulation. Attentional deployment may refer to either selective attention (focusing attention towards or away from a stimulus) or distraction (deliberately focusing attention on events other than the relevant stimuli) as strategies to regulate development of emotional states. For example, across two studies using adult cohorts ($n$ = 16 and $n$ = 11, respectively), an increase of activation within the right lateral frontal cortex correlated with a concurrent decrease in amygdala activity while participants were asked to engage in a labelling task while viewing evocative images (Hariri et al., 2000; Hariri et al., 2003). Appraisal and labelling of an aversive affective state has been seen to increase activation in the medial and lateral frontal cortices (Denson et al., 2009; Lieberman, 2007), which then shape physiological and behavioural responses through projections to subcortical areas including the amygdala and PAG (An et al., 1998).

Cognitive change, the second process identified by Ochsner and colleagues (2012), refers to changes in the way an individual appraises a situation. Specifically investigating how reappraisal affects neural activation, Fabiansson and colleagues (2012) requested that participants recall an anger-inducing autobiographical event, and either reappraise the situation, analytically ruminate about the situation, or angrily ruminate about the situation. All conditions correlated with activation in the frontal cortex, however, whereas both rumination conditions positively correlated with an increase in amygdala activation, the reappraisal condition did not relate. Moreover, the reappraisal condition produced the lowest levels of self-reported anger. In other words, reappraisal of an anger-inducing memory related to the downregulation of subcortical activity and self-reported levels of anger (Fabiansson et al., 2012).

Response modulation, the third process identified by Ochsner and colleagues (2012), refers to strategies to inhibit emotion-expressive behaviour, typically with nominal

change to the ongoing emotion, and an increase in sympathetic arousal (Gross, 2002). Evidence suggests that long-term use of this strategy relates to decreased control of the targeted emotion and interpersonal functioning (Gross & John, 2003). While there have been no investigations into how suppression of anger relates to neural functioning, inferences can be drawn from investigations into other aversive affective states. For example, Phan and colleagues (2005) observed that after asking an adult cohort ($n$ = 14) to suppress negative emotions – no particular emotion was identified in this investigation – while viewing emotionally evocative images (e.g. burn victims, dead animals), activation was seen in the right dorsomedial, dorsolateral, and ventrolateral prefrontal cortices. Asking a sample of adult women ($n$ = 17) to suppress, rather than reappraise, negative emotions experienced while watching disgust-inducing videos (e.g. surgical procedures, animal slaughter), Goldin and colleagues (2008) reported increased activation in the medial and inferior prefrontal cortices, concurrent with increased activation in the amygdala. Suppressing behavioural responses results in similar patterns of activation as those that are related to suppressing emotions. Using a Go/No-go paradigm with a sample of adults ($n$ = 18), Fassbender and colleagues (2004) reported that successful inhibition of behavioural responding was associated with increased activation in the right ventral prefrontal and left dorsolateral cortices. In a similar paradigm, Rubia and colleagues (2001) saw increased activation in the medial and inferior frontal cortices.

To summarize what is currently understood about the neural network associated with the experience of anger, we can see that many distinct regions are involved and that processes occur at multiple levels, often forming cyclic relationships. It is thought that early, and autonomic, processes occurring the PAG and hypothalamus provide the initial physiological effects (e.g. heart rate, blood pressure) related to anger (Behebhani, 1995; Panksepp, 1998). Receiving input from the PAG and hypothalamus, the amygdala influences the emotional salience of the event and, likely due to its role in fear-conditioned

learning, influences the likelihood of anger-related behaviour (i.e. aggression; Aggleton, 1993; Phelps, 2004). The frontal cortices receive both direct and indirect input from the preceding areas (Panksepp, 1998; Sah et al., 2003), and act to inhibit the experience and expression of anger through processes that occur as antecedent-focused (i.e. attentional deployment, cognitive change) – i.e. influencing cognitive tendencies before they give rise to a response – or response-focused (i.e. response modulation) – i.e. influencing emotional responses after they have occurred – strategies (Fuster, 2001; Hariri et al., 2003; Konishi et al., 1999). The frontal cortices then project back to the midbrain regions (An et al., 1998) reducing activity if regulation strategies were successful, or if regulation was unsuccessful creating a feedback loop that increases midbrain activity (Gross, 2002) – such as that seen related to rumination (Fabiansson et al., 2012), and finally influencing a behavioural response from the PAG.

## Thesis outline and aims

The goal of this thesis is to further current understandings of how individual differences influence the pathway towards anger and the closely related constructs of hostility and aggression. To this end, the first chapter has reviewed the appropriateness and importance of examining anger from an individual differences perspective, the measures commonly used to quantify facets of anger, how these measures relate to core personality factors, and finally models of anger developed by researchers considering the roles of individual differences (alongside situational and structural factors).

This thesis will investigate and address gaps in the literature pertaining to several domains described by the models of anger outlined above. Firstly, very little is known about the how discrete factors of core personality interact to influence the pathway towards anger. More specifically, how do the conditional effects of core personality factors, whose

direct effects are associated with either increasing or decreasing the likelihood of experiencing anger, predict angry outcomes? To this end, Chapter 2 details how a large, US-representative sample was investigated to determine how interactions amongst personality traits predict the overall experience and expression of anger. Previous investigations suggest that the Big Five trait associated with increases in the likelihood or intensity of anger is neuroticism (e.g. Edmunds, 1977; Hennig et al., 2005), while the ability to inhibit the development of or control the expression of anger is most associated with both conscientiousness (e.g. Tremblay & Ewart, 2005) and agreeableness (e.g. Egan & Campbell, 2009; Hofmans et al., 2008). While considerable work has examined how these core factors relate to anger, less attention has been paid to the role of interactions amongst core factors. Therefore, an investigation into moderating effects between neuroticism, conscientiousness, and agreeableness was conducted.

An important component on the pathway towards anger, interpreting transgressions to be intentional (rather than accidental) is more likely to give rise to anger (Berkowitz & Harmon-Jones, 2004). Despite the importance of this component, there is a dearth of literature addressing how higher and lower order traits predict such judgments. Therefore and secondly, Chapter 3 describes two studies which investigated how judgments of hostile intent are shaped by core personality factors, and whether higher-order constructs mediate this relationship.

Finally, examining the trait-level experience of anger and its various expressions, an investigation into how variations in cortical gray matter (GM) volume correlate with trait anger and its expressions (i.e. anger expression-in, anger expression-out, anger expression-control) was conducted. Multiple studies have identified anger-related activation within brain regions, yet little work has directly addressed the GM correlates of anger (but see Reuter et al., 2009), despite volumetric differences in GM being associated

with performance across multiple cognitive tasks (Gur et al., 1999), and lesions to GM being associated with increased angry affect (Panksepp, 1998, p. 196) in animal models.

# Chapter 2

# An angry personality: Evidence of direct and interactive effects amongst core personality traits

(based on: **Pease CR,** Lewis GJ (2015) Personality links to anger: Evidence for trait interaction and differentiation across expression style. Personality and Individual Differences, 74, 159-164.)[1]


## Abstract

Anger is a commonly experienced emotion, although marked individual differences in the expression of anger are observed. Basic dimensions of personality (Big Five traits) have been shown to predict the experience of anger; however, little work has addressed the personality correlates of broader conceptualisations of anger (e.g. inward or outward expressions). Additionally, while some recent work has suggested that basic personality traits may show interactive influences on anger expression this work has yet to be independently confirmed. In a large sample of adults we examined, firstly, how personality traits associated with several components of anger as measured by the State-Trait Anger Expression Inventory. Secondly, we examined whether these associations were further qualified by interactions between personality traits. Results indicated neuroticism and, to a lesser extent, agreeableness were the traits most associated with components of anger. Conscientiousness and extraversion were also noted to show links to more focal components of anger. Moderation was observed: conscientiousness moderated neuroticism's relationship with anger control, and agreeableness and conscientiousness, in a three-way interaction, moderated neuroticism's relationship with trait anger. These


[1] The author designed the experiment, analyzed the results, and wrote the article under supervision of Dr. Gary J Lewis

observations help to further clarify the role of basic personality as a foundation for the experiences of anger, demonstrating how anger style varies across personality configuration.

## Introduction

The aetiology of anger and aggression has been a topic of enduring interest for behavioural scientists. Much work has unveiled the situational (Anderson & Bushman, 2002; Anderson, Deuser, & DeNeve, 1995; Venable, Carlson, & Wilson, 2001), dispositional (Edmunds, 1977; Miller, Zeichner, & Wilson, 2012), and cognitive (Anderson & Bushman, 2002; Hoaken, Shaughnessy, & Pihl, 2003; Wilkowski & Robinson, 2008) factors that give rise to anger. However, anger is known to be a complex construct and the foundational personality traits (e.g. the Big Five) that shape the different experience or expression of anger are less well understood. Furthermore, recent work suggests that interactions between personality influences on anger expression may be an additional source of prediction (Jensen-Campbell et al., 2007; Ode et al., 2008), although these claims have also received limited attention to date. The goal of the current study, then, was to examine the relationship between Big Five personality traits and several aspects of anger expression. Moreover, we sought to test whether interactions between Big Five traits provided incremental validity in the prediction of anger expression. To this end we analysed data from a large, representative sample of US adults (Ryff et al., 2012; Ryff et al., 2013) who had completed measures of Big Five traits along with a comprehensive anger expression measure. Next we detail previous work linking components of anger and personality, before moving to tests of our hypotheses.

**Personality and Anger: A Brief Overview**

While much of the personality research to date addressing anger has focused on higher-order constructs (e.g., narcissism, psychopathy; Blair, Mitchell, & Blair, 2005; Kaukiainen et al., 1999; Locke, 2009), in recent years a move toward understanding anger through basic dimensions of personality has emerged (Jones, Miller, & Lynam, 2011). This approach is welcome, as it allows theories of anger to be situated in a rich body of work that examines the more nuanced factors or constructs that contribute to or inhibit the propensity for anger.

Of this research, a number of key findings are apparent. Firstly, neuroticism is a strong predictor of anger and hostility (Sharpe & Desai, 2001: see also Hofmans et al., 2008; Ode et al., 2008; Tremblay & Ewart, 2005; Sharpe & Desai, 2001), but less so to aggression (Egan & Campbell, 2009; Sharpe & Desai, 2001). Furthermore, differentiating between styles of anger expression (i.e., anger-in, anger-out) demonstrates variation in neuroticism's relationship, with increased correlations with inwardly expressed anger compared to outwardly-expressed anger-out (Martin et al., 1999).

Secondly, agreeableness shows a consistent inverse relationship with anger (Egan & Campbell, 2009; Graziano & Tobin, 2002; Hofmans et al., 2008; Meier & Robinson, 2004), as well as related constructs such as aggression (Fossati et al., 2009; Jones et al., 2011; Miller et al., 2012; Seibert et al., 2010) and hostility (Barefoot et al., 1989; Sharpe & Desai, 2001). Of the single study to address the role of agreeableness to sub-components of anger, agreeableness was seen to be inversely related to both internal ($r$ = -.36) and external expressions ($r$ = -.55; Martin et al., 1999), suggesting that not only does (low) agreeableness serve as a predictor for anger, but it also influences the affective style of anger with emphasis on avoiding outward expressions of anger.

Thirdly, several studies have demonstrated an inverse relationship between conscientiousness and both anger and aggression (Burton et al., 2007; Lee & Dow, 2011; Miller et al., 2012; Tremblay & Ewart, 2005). Moreover, Martin et al. (1999) reported an inverse relationship between conscientiousness and both inwardly-expressed anger ($r$ = -.20) and outwardly-expressed anger ($r$ = -.24). Noting correlates between conscientiousness and self-control, Jensen-Campbell and colleagues (2007) assert that conscientiousness plays an important role in inhibiting responses, during frustrating interpersonal situations, which may be counter to the individual's overarching goals; moderating anger's pathway towards aggression and facilitating adherence to social self-regulation precepts.

The remaining two Big Five traits' links to anger are less well established, although there is evidence that these dimensions may also be relevant. Extraversion has rarely shown links to anger and aggression, although some work has shown an inverse relationship between inwardly-expressed anger and extraversion ($r$ = -.36: Martin et al., 1999), and Miller et al. (2012) found that the extraversion facet of excitement seeking had a significant relationship to reactive aggression ($r$ = .31). Finally, openness has received only modest attention with regards to anger and aggression, with limited evidence for an association (Bettencourt et al., 2006; Jones et al., 2011; Miller et al., 2012).

**Multifaceted Anger**

While links between personality links to broad-based anger have been examined in several studies, to date there has been a lack of recognition of the fact that anger is a multi-faceted construct, with the affective experience of anger able to be expressed in multiple ways. For example, the Spielberger State-Trait Anger Expression Inventory (STAXI; Spielberger, 1988) fractionates anger into state and trait components. The STAXI further delineates these levels by identifying the potential expression of anger-in (AX/IN; internally directed

expressions), anger-out (AX/Out; externally directed expressions), and anger-control (AX/C; effectively managing anger in accordance with one's goals). Variations within anger styles have been differentially associated with both physical and mental health outcomes (Martin et al., 1999; Schröder-Abe, et al., 2007) suggesting that distinguishing between these components is important. It is notable, however, that while Big Five personality associations with anger have been examined, this work has rarely addressed different components of anger, with the sole study (Martin et al., 1999), of which we are aware, to address the more nuanced aspect of anger expression style and its link to personality being limited to a student sample, suggesting replication in broader samples will be valuable.

**Personality Trait Interactions and Anger**

Additionally, while specific Big Five traits show robust and often sizeable links to anger and aggression, almost no attention to date has been focussed on whether these traits show interactive influences with regards to their effects on anger expression. This is unfortunate as several models of anger (and aggression) explicitly contain such interactive elements in ways that directly implicate Big Five traits (DeWall et al., 2011; Slotter & Finkel, 2011; Wilkowski & Robinson, 2010). Recent work that has begun to address these concerns led to the observation that agreeableness moderated the influence of neuroticism on anger (Ode et al., 2008). Additionally, conscientiousness has been noted to moderate anger's pathway to aggression and agreeableness's relationship with anger (Jensen-Campbell et al., 2007). Both of these studies, however, were conducted with undergraduate samples and/or samples of modest size. It is important, therefore, to establish the robustness and generalizability of these effects in large and non-student samples.

**The Current Study**

Anger is a multi-faceted construct, as evidenced by the diversity of scales and sub-scales present in the literature (DeWall et al., 2011; Slotter & Finkel, 2011; Spielberger 1988; Wilkowski & Robinson, 2010). In addition, the importance of trait interactions in determining anger have been examined only in a handful of studies to date, and none to our knowledge capturing a broad-based assessment of anger. With this in mind, the core goals of the current study were as follows. First, we sought to examine the role of basic personality traits across a range of anger types in order to more comprehensively address the role of personality on anger. To this end we utilized the well-characterised State-Trait Anger Expression Inventory (STAXI; Spielberger, 1996). This self-report measure examines anger at both the state and trait levels, as well as measuring anger expression as anger-in (intra-directed expression), anger-out (inter-directed expression), and anger control (ability to effectively control affective arousal). Second, we sought to assess how these traits might interact to predict anger.

We predicted that neuroticism and (low) agreeableness would reflect anger expression of all types with an emphasis on anger-in and anger-out, respectively. In addition, we hypothesized that conscientiousness would specifically predict anger control, but also reduced levels of other expressions. We did not make further specific predictions because of the limited previous work to generate hypotheses. Finally, we predicted that the strength of neuroticism's association with anger would be moderated by agreeableness, in line with Ode et al. (2008). We also explored whether the strength of agreeableness's association with anger was moderated by conscientiousness, in line with Jensen-Campbell et al. (2007). Although no work (to our knowledge) has demonstrated a role for conscientiousness as a moderator on the effects of neuroticism to anger, we also examined whether this effect as well as whether a three-way interaction between these variables

(agreeableness × neuroticism × conscientiousness) was present, in line with the broader arguments noted above by Ode et al. (2008) and Jensen-Campbell et al. (2007). Finally, in line with the close links between anger and aggression, and the availability of an aggression measures in the dataset we used in this study, we also extended our analyses to include test of how personality trait interactions predicted aggression.

## Methods

### Participants

To test our predictions we used a large, representative sample of US adults. Data was available for 1631 participants selected from the main sample of the National Survey of Midlife Development in the United States II (MIDUS II; Ryff et al., 2012; Ryff et al., 2013) who were assessed on the Big Five personality traits, acts of aggression determined by the MPQ, and the STAXI, among other measures. The sample consisted of 901 males (mean age = 56.85; SD = 12.64) and 730 females (mean age = 57.53; SD = 12.53). By race, 88.9% (*n* = 1450) of the sample was comprised of individuals identifying as White, 4.3% (*n* = 71) as Black, 0.5% (*n* = 8) as Native American or Aleutian Islander/Eskimo, 0.7% (*n* = 12) as Asian or Pacific Islander, 1.5% (n=24) as Other, 0.6% (*n* = 10) as Multiracial, and 3.5% (*n* = 56) refused or were missing data on this questions.

### Measures

**Personality Traits.** Personality traits were measured as part of a larger personality assessment examining neuroticism, agreeableness, extraversion, openness to experience, and conscientiousness (Lachman & Weaver, 1997). Traits were measured by asking participants to use a four-point Likert scale to rate the degree to which self-descriptive

adjectives (e.g., helpful, warm, moody, worrying) described them. The mean from each set of items was then calculated to define the trait scales. Cronbach's alpha for each of the personality measures neuroticism, agreeableness, extraversion, openness to experience, and conscientiousness are .74, .81, .77, .78, .70, respectively.

**Anger and Anger Expression.** Data was available from participants' self-administration of the Spielberger State-Trait Anger Expression Inventory (Spielberger, 1996), and reported scores for the scales Trait Anger (T-Ang), Anger Expression–In (AX/IN), Anger Expression-Out (AX/Out), and Anger Control (AX/C). The scale of T-Ang contains two subscales, which are also briefly reported on here: Angry Temperament (T-AngT) and Angry Reaction (T-AngR). The STAXI scales consisted of four to fifteen items which participants rated on a four-point Likert scale. Example items include: "I have a fiery temper" (T-Ang), "I boil inside, but don't show it" (AX/IN), "I strike out at whatever infuriates me" (AX/Out), and "I keep my cool" (AX/C). Scale scores were constructed by the summing across items for which there was no or only one missing value. Mean substitution was used for cases which had only one missing value (Ryff et al., 2013). The State Anger subscale was not measured as part of the STAXI within the MIDUS II, and therefore not reported here. Cronbach's alpha for the T-Ang, T-AngT, T-AngR, AX/IN, AX/Out, and AX/C were .82, .80, .73, .81, .75, and .68, respectively.

**Aggression.** Aggression was measured as a subscale of the self-administered Multidimensional Personality Questionnaire (MPQ; Tellegen, 1985; Patrick, Curtin, & Tellegen, 2002). The aggression subscale consisted of four items which participants rated using a four-point Likert scale. An example item is: "Sometimes I just like to hit someone". The sum of the value of the items constructed the scale with higher scores reflecting increased amounts of aggression. Cronbach's alpha for the aggression facet of the MPQ was .65.

## Results

Descriptive statistics and correlation coefficients for each of the variables are presented in Tables 2.1 and 2.2. T-Ang's strongest correlation was with neuroticism ($r$ = .36, p < .001). The subscale AX/IN was most strongly associated with extraversion ($r$ = -.33, p < .001), closely followed by neuroticism ($r$ = .32, p < .001). The trait most strongly correlated with AX/Out was neuroticism ($r$ = .23, p < .001). The subscale AX/C was most strongly correlated with neuroticism ($r$ = -.31, p < .001). Aggression was most correlated with neuroticism ($r$ = .29, p < .001), closely followed by agreeableness ($r$ = -.28, p < .001).

Table 2.1. *Descriptive statistics for study variables.*

| | Mean | SD | N |
|---|---|---|---|
| N | 2.08 | .63 | 1621 |
| A | 3.44 | .51 | 1622 |
| E | 3.10 | .58 | 1622 |
| O | 2.91 | .54 | 1609 |
| C | 3.38 | .47 | 1621 |
| T-Ang | 24.04 | 5.18 | 612 |
| T-AngT | 5.11 | 1.61 | 614 |
| T-AngR | 7.77 | 2.41 | 614 |
| AX/IN | 14.77 | 4.11 | 614 |
| AX/Out | 12.94 | 3.21 | 615 |
| AX/C | 9.99 | 2.25 | 615 |
| Aggression | 5.46 | 1.82 | 1622 |
| Age | 57.15 | 12.59 | 1631 |

Note: N = Neuroticism; A = Agreeableness; E = Extraversion; O = Openness; C = Conscientiousness; T-Ang = Trait Anger; T-AngT = Trait Anger: Angry Temperament; T-AngR = Trait Anger: Angry Reaction; AX/IN = Anger Expression: Anger-In; AX/Out = Anger Expression: Anger-Out; AX/C = Anger Expression: Anger-Control.

Table 2.2. *Correlations among personality, anger, aggression, and demographic variables.*

| Measure | N | A | E | O | C | T-Ang | T-AngT | T-AngR | AX/IN | AX/Out | AX/C | Agg | Age |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | **-.11** | | | | | | | | | | | | |
| E | **-.20** | **.53** | | | | | | | | | | | |
| O | **-.21** | **.36** | **.52** | | | | | | | | | | |
| C | **-.18** | **.30** | **.30** | **.35** | | | | | | | | | |
| T-Ang | **.36** | **-.19** | **-.18** | -.12** | **-.18** | | | | | | | | |
| T-AngT | **.33** | -.11** | -.03 | -.05 | -.11** | **.64** | | | | | | | |
| T-AngR | **.18** | -.11** | **-.13** | -.05 | -.04 | **.82** | **.27** | | | | | | |
| AX/IN | **.32** | **-.23** | **-.33** | **-.17** | **-.15** | **.47** | **.18** | **.41** | | | | | |
| AX/Out | **.23** | **-.14** | .00 | .01 | **-.14** | **.55** | **.57** | **.33** | **.19** | | | | |
| AX/C | **-.31** | .11** | .10** | **.14** | **.19** | **-.28** | **-.33** | **-.13** | **-.13** | **-.31** | | | |
| Aggression | **.29** | **-.28** | **-.14** | **-.13** | **-.22** | **.44** | **.40** | **.26** | **.31** | **.32** | **-.21** | | |
| Age | **-.20** | **.10** | .03 | -.02 | -.03 | **-.12** | -.09** | **-.10** | **-.25** | **-.23** | .02 | **-.12** | |
| Gender | **.16** | **.32** | **.09** | **-.08** | **.09** | .04 | .00 | .06 | -.05 | .01 | -.08* | **-.17** | -.03 |

Note: N = Neuroticism; A = Agreeableness; E = Extraversion; O = Openness; C = Conscientiousness; T-Ang = Trait Anger; T-AngT = Trait Anger: Angry Temperament; T-AngR = Trait Anger: Angry Reaction; AX/IN = Anger Expression: Anger-In; AX/Out = Anger Expression: Anger-Out; AX/C = Anger Expression: Anger-Control; *n* = 636-1801; Gender: Male = 1; Gender: Female = 2; Bolded = $p < .001$; ** $p < .01$; * $p < .05$.

To test for unique effects of Big Five personality on anger, we used linear regression analyses with T-Ang, AX/IN, AX/Out, AX/C, and aggression as dependent variables, respectively. Age and gender were included as covariates in each model. Full model outputs are presented in Table 2.3. In brief, T-Ang was most strongly predicted by neuroticism ($\beta$ = .33, p < .001). AX/IN was most strongly predicted by neuroticism ($\beta$ = .24, p < .001) and extraversion ($\beta$ = -.27, p < .001); additionally, age was a predictor ($\beta$ = -.19, p < .001). AX/Out was most strongly predicted by neuroticism ($\beta$ = .19, p < .001), closely followed by agreeableness ($\beta$ = -.15, p < .01); with age as an additional predictor ($\beta$ = -.20, p < .001). AX/C was strongly predicted by neuroticism ($\beta$ = -.29, p < .001). Finally, aggression was most strongly predicted by neuroticism ($\beta$ = .29, p < .001), followed by agreeableness ($\beta$ = -.21, p < .001); gender ($\beta$ = -.15, p < .001) was also a significant predictor.

Table 2.3. *Linear regression analyses (with standardized beta coefficients) showing personality and demographic effects on the seven outcome variables.*

| | T-Ang (*n* = 598) | T-AngT (*n* = 600) | T-AngR (*n* = 600) | AX/IN (*n* = 600) | AX/Out (*n* = 601) | AX/C (*n* = 601) | Aggression (*n* = 1591) |
|---|---|---|---|---|---|---|---|
| N | **.33** | **.34** | **.16** | **.24** | **.19** | **-.29** | **.29** |
| A | -.12** | -.09* | -.08 | -.02 | -.15** | .08 | **-.21** |
| E | -.06 | .09 | -.09 | **-.27** | .11* | -.04 | .05 |
| O | .04* | .02 | .05 | .05 | .09 | .04 | .00 |
| C | -.08* | -.04 | .01 | -.07 | -.13** | .13** | **-.10** |
| Age | -.03 | -.01 | -.05 | **-.19** | **-.20** | -.06 | -.06* |
| Gender | .04 | -.03 | .06 | -.06 | .02 | -.08 | **-.15** |
| F | **17.40** | **12.44** | **5.52** | **25.24** | **13.92** | **13.49** | **53.41** |
| $R^2$ | **.17** | **.13** | **.06** | **.23** | **.14** | **.14** | **.19** |

Note: N = Neuroticism; A = Agreeableness; E = Extraversion; O = Openness; C = Conscientiousness; T-Ang = Trait Anger; T-AngT = Trait Anger: Angry Temperament; T-AngR = Trait Anger: Angry Reaction; AX/IN = Anger Expression: Anger-In; AX/Out = Anger Expression: Anger-Out; AX/C = Anger Expression: Anger-Control; *n* refers to the number of participants for whom complete data was available after listwise deletion; Gender: Male = 1; Gender: Female = 2; Bolded = $p < .001$; ** $p < .01$; * $p < .05$.

To test our hypotheses concerning moderation we used a series of hierarchical linear regression models with anger styles and aggression as dependent variables. Big Five traits were entered in step 1, two-way interaction terms (neuroticism×agreeableness, neuroticism×conscientiousness, conscientiousness×agreeableness) were entered in step 2, and the three-way interaction term (neuroticism×agreeableness×conscientiousness) was entered in step 3. Age and sex were included as covariates. All continuous predictor variables were mean centred, and interaction terms were created as the product of the relevant mean-centred variables. As above, we tested each of dependent variables in separate analyses. Interactions were then probed across values of moderator variables (±1 SD from the mean) according to techniques described by Preacher and colleagues (2003). Unstandardized coefficients are the preferred metric in moderation modelling (Hayes, 2008), and as such are reported here. These analyses revealed several significant effects. Specifically, a 2-way interaction was observed in which conscientiousness moderated neuroticism's pathway to AX/C ($b$ = .626, $t(598) = 2.07$, $p < .05$); such that the inverse relationship between neuroticism and AX/C was significantly more pronounced at lower levels of conscientiousness (see Figure 2.1). Three 3-way interactions were observed in which conscientiousness moderated agreeableness's influence on neuroticism's pathway to T-Ang ($b$ = 3.45, $t(594) = 2.78$, $p < .01$), the pathway to AX/Out ($b$ = 1.76, $t(597) = 2.24$, $p < .05$), and the pathway to aggression ($b$ = -.59, $t(1587) = -2.84$, $p < .01$) (see Figures 2.2-2.4).

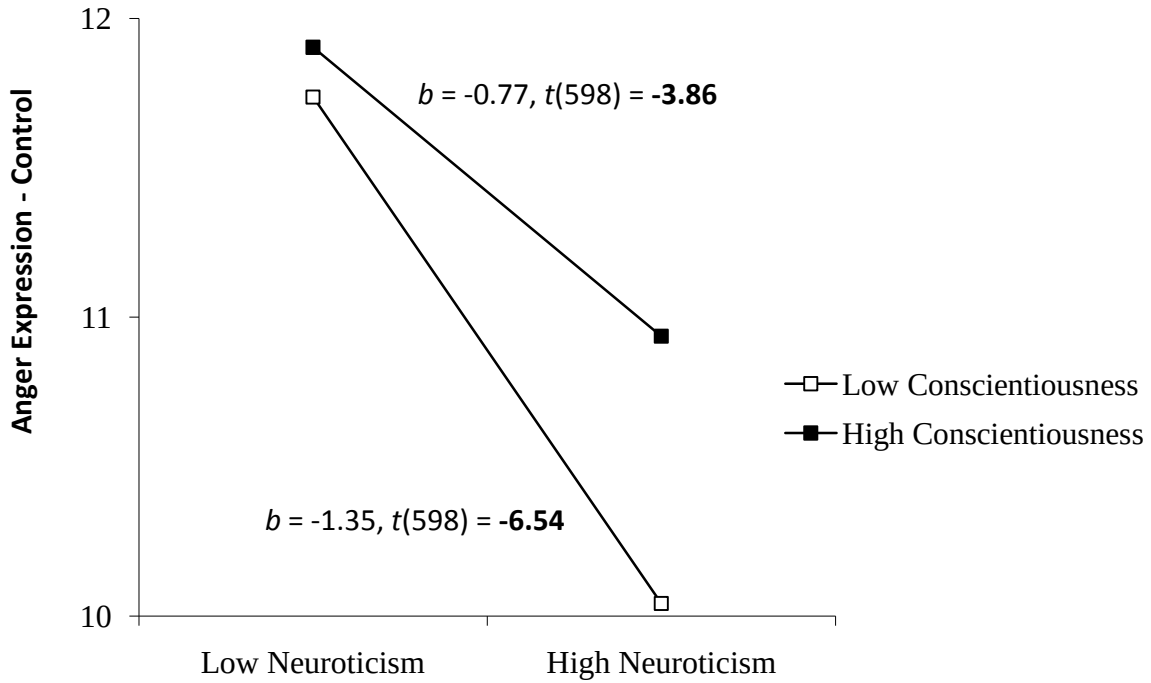


*Figure. 2.1*. Conscientiousness's moderating effect on neuroticism's pathway to Anger Expression - Control. Bolded = $p < .001$; ** $p < .01$; * $p < .05$.

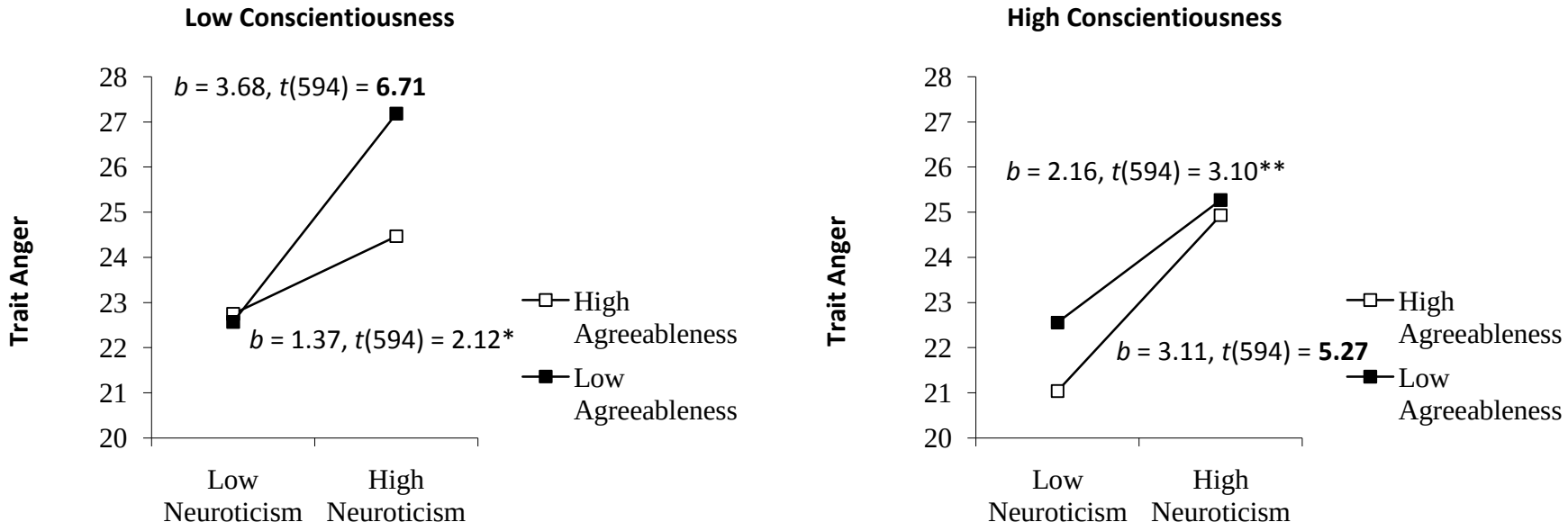


*Figure. 2.2.* Agreeableness's moderating effect on neuroticism's pathway to Trait Anger, at ±1 standard deviation from the mean for conscientiousness. Bolded = $p < .001$; ** $p < .01$; * $p < .05$.

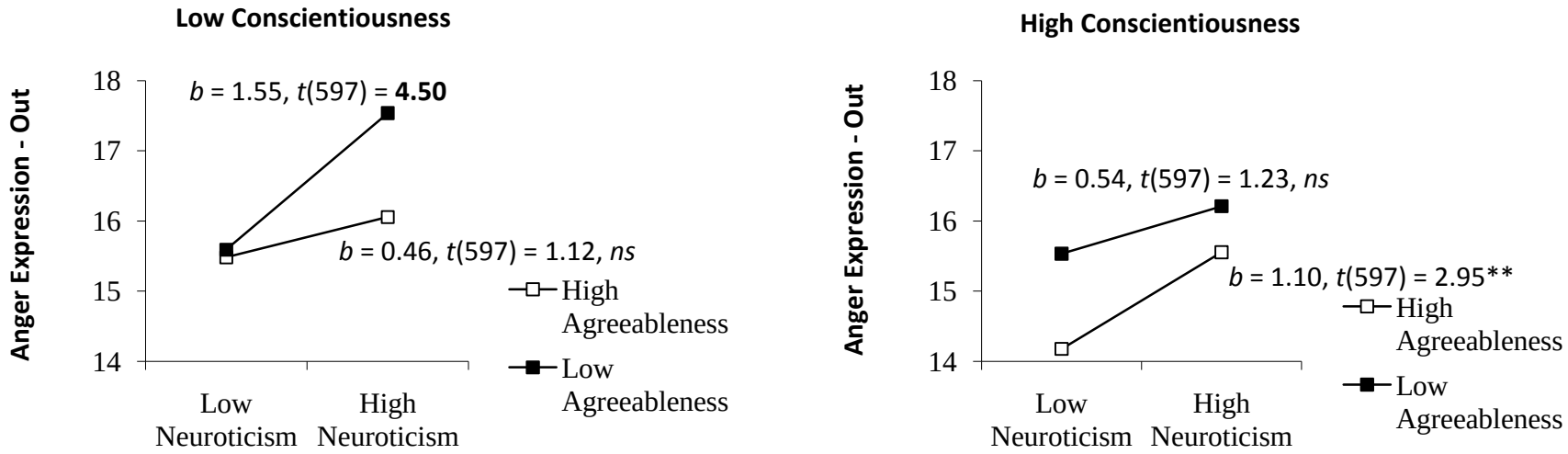


*Figure 2.3.* Agreeableness's moderating effect on neuroticism's pathway to Anger Expression - Out, at ±1 standard deviation from the mean for conscientiousness. Bolded = $p < .001$; ** $p < .01$; * $p < .05$.

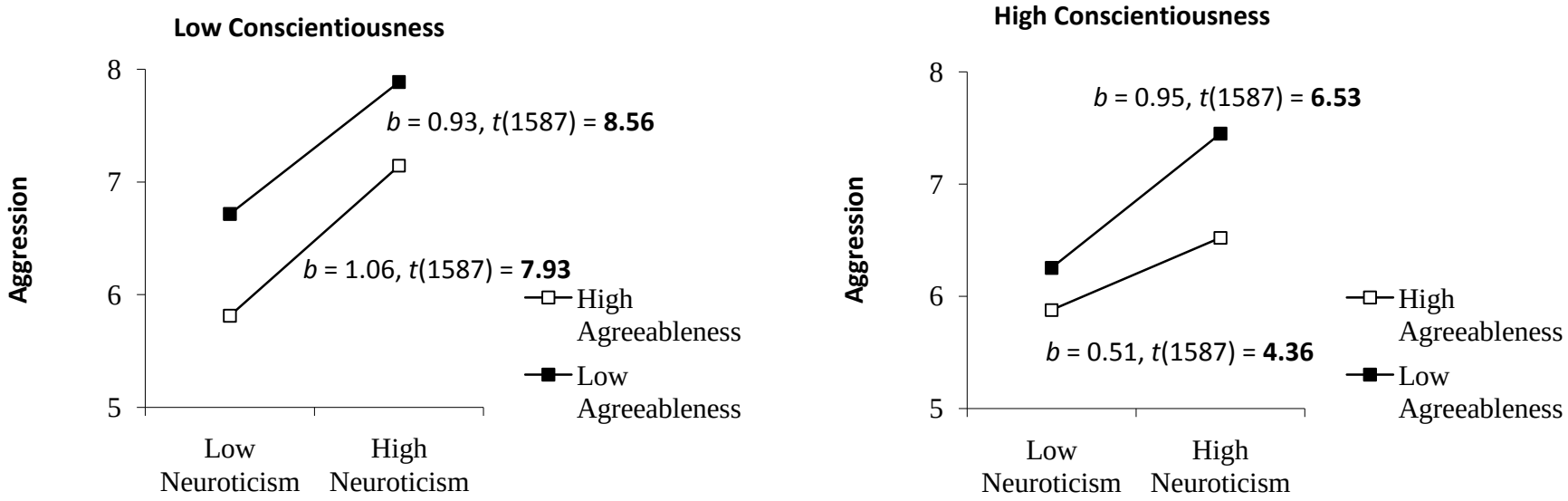


*Figure 2.4.* Agreeableness's moderating effect on neuroticism's pathway to aggression, at ±1 standard deviation from the mean for conscientiousness. Bolded = $p < .001$; ** $p < .01$; * $p < .05$.

## Discussion

As expected, neuroticism was a powerful predictor of all outcome variables and agreeableness was a significant inverse predictor of Anger-Out (AX/Out), aggression, and Trait Anger (T-Ang). Consistent with our second hypothesis, conscientiousness was a significant predictor of Anger Control (AX/C), as well as AX/Out, aggression, and T-Ang. Extraversion was a significant and inverse predictor of both the style Anger-In (AX/IN) and AX/Out. Finally, openness was predictive, albeit modestly, of T-Ang levels. These findings broadly replicate previous work looking at anger expression (Martin et al., 1999) and suggest that anger expression is underpinned by multiple personality constructs.

We found neuroticism to be the most powerful predictor of all anger styles and aggression. Its predictive ability of anger is perhaps not surprising. The trait neuroticism is largely defined by a heightened sensitivity to potential transgressions and sense of affective arousal. Its predominant relationship with aggression was more unexpected. On one hand a high-neuroticism individual is more likely to become angry and experience greater levels of anger. However, several of neuroticism's facets (i.e., anxiety, self-consciousness, vulnerability) seem intuitively opposed to the potential risks (e.g., physical or verbal assault) associated with confronting another individual. One potential reason for these results might be found by reviewing the items of the aggression measure. Three of the four items address a reactive form of aggression (e.g., "When people insult me, I try to get even").With evidence of neuroticism's greater relation to reactive aggression (Fossati et al., 2009; Miller & Lynman, 2006) it is perhaps not entirely surprising that a relationship is seen here.

Evidence for moderation was also observed. Conscientiousness had a moderating effect on the pathway between neuroticism and AX/C; such that the link between

neuroticism and AX/C was stronger when levels of conscientiousness were lower. This interaction was interpreted as evidence for the cooling or dampening effect of an underlying system reflecting diligence and the ability to inhibit impulsive or spontaneous responses (i.e. conscientiousness) on a system reflecting emotional volatility and a general negative affect (i.e. neuroticism). We also observed that agreeableness moderated neuroticism's link to T-Ang, AX/Out, and aggression as a function of conscientiousness. We interpreted these interactions as evidence for the dynamic interplay where a system reflecting diligence to social rules or norms (i.e. conscientiousness) emphasizes the importance of acting upon one's motivation to avoid harming or exploiting others (i.e. agreeableness) following the experience of anger associated with higher levels of neuroticism.These findings support recent models of anger and aggression (DeWall et al., 2011; Slotter & Finkel, 2011; Wilkowski & Robinson, 2010) that emphasize a more interactive framework for understanding such behaviour and indicate that personality researchers should undertake more systematic work of this kind.

While our study benefitted from the use of a large, nationally representative sample, specific limitations and recommendations for future work should be noted. Firstly, our measure of Big Five traits was a short-form instrument and so may have lacked comprehensive coverage of the domain space. Secondly, we relied on self-report for our measure. While this is not uncommon in the literature, it is possible that bias in reporting for socially sensitive measures such as anger expression may have limited the validity of our findings. A potential third limitation was the cross-sectional approach to data used in this investigation and the causal inferences made regarding personality and the experience of anger. The nature of the MIDUS allows for the longitudinal analysis of participants' data, perhaps offering a more robust claim to any causality. For example, by analysing changes in a participants' neuroticism scores relative to changes in trait anger scores, one may be able to more strongly infer causality if the evidence indicates both change in the

same direction. Future work is recommended that uses independent anger scores, such as peer rating, and/or longitudinal analysis.

In summary, we found personality traits to be significant predictors of anger expression and also of aggression. High neuroticism and low agreeableness were both linked with enhanced expressions of anger and aggression, and we also found a role for conscientiousness on anger control and for extraversion on inwardly-expressed anger. We observed conscientiousness's moderation of neuroticism's pathway to anger control and a three-way interaction of conscientiousness × agreeableness moderating neuroticism's pathway to trait anger, outwardly-express anger, and aggression. This work provides support for recent theoretical models of anger and aggression emphasizing that interactive components underpin such behaviours and suggest that adopting this dynamical approach may be of value to the field.

# Chapter 3

# "The world has got it in for me!" The role of personality in judgements of hostile intent

## Introduction

Most major models of anger (DeWall et al., 2011; Wilkowski & Robinson, 2008), identify that whether an individual appraises a harmful act to be intentional or not is an important component on the pathway towards anger. However, little is known regarding how individual differences relate to the processes underlying judgements of hostile intent. Identifying the constructs – such as basic personality traits – that influence such judgements will allow for more detailed models of anger to be generated. To this end, across two independent studies we examined, firstly, how basic traits of personality were

associated with judgments of hostile intent (Study 1), and, secondly, whether these effects were mediated via constructs reflecting a sense of self-entitlement, sensitivity to being socially usurped, or social projection of one's own traits (Study 2).

Additionally, because recent evidence suggests that, compared to a five-factor model of personality, a six factor model (i.e. HEXACO) provides increased predictive validity of several related constructs, such as trust in others (Thielmann & Hilbig, 2014) and a tendency to retaliate following transgressions (Hilbig, Zettler, Leist, & Heydasch, 2013), related to interpersonal outcomes (for review a more complete review, see Ashton, Lee, & de Vries, 2014), we also sought to test that this relationship exists regarding judgments of hostile intent. To this end we also collected and analyzed Big Five trait data using the BFI (John & Srivastava, 1999) to assess whether the HEXACO framework provides incremental validity. Next we briefly introduce previous research examining judgements of hostile intent and what is currently understood about how they relate to individual differences before moving to empirical tests of personality links to judgements of hostile intent.

**Judgements of Hostile Intent: A Brief Overview**

Harmful acts are not appraised equally, and aversive events that are judged to be intentional (rather than accidental) are typically considered to be more unpleasant and are also more likely to give rise to anger (Berkowitz & Harmon-Jones, 2004). Evidence indicates that judgments of hostile intent are typically an automatic process (Copello & Tata, 1990; Hazebroek, Howells, & Day, 2001; Wilkowski & Robinson, 2008; Wingrove & Bond, 2005; Zelli, Cervone, & Huesmann, 1996; Zelli, Huesmann, & Cervone, 1995), implicated in evoking anger (Rudolph, Roesch, Greitemeyer, & Weiner, 2004; Smith, Haynes, Lazarus, & Pope, 1993), while increasing the intensity of anger (Epps & Kendall, 1995; Graham, Hudley, & Williams, 1992; Hazebroek, Howells, & Day, 2001.

**A Role for Personality**

Despite the important role judgements of hostile intent play in subsequent expressions of anger and aggression (Crick & Dodge, 1996; Anderson & Bushman, 2002), little empirical attention has been paid to how such factors are related to individual differences in personality. Identifying the core personality predictors of a tendency to judge others' harmful actions as intentional will add understanding to a core component in the causal pathway of anger and aggression.

Core personality models (e.g., HEXACO, Big Five) represent a strong platform with which to initiate research examining individual differences related to judgements of hostile intent. Conceptualized as stable psychobiological systems that reflect low-level processes such as sensitivity to rewards, sensitivity to punishments, and impulse control (DeYoung, 2010; McCrae & Costa, 2008), core personality traits are argued to have downstream consequences, in an additive or interactive fashion, on cognitive processes such as judgements of hostile intent. Previous investigations looking at associations between personality and hostility have done so by operationalizing hostility as a broadly defined personality trait (Eckhardt, Norlander, & Deffenbacher, 2004) affecting outcomes such as interpersonal relations (Brondolo et al., 2003) and long-term health outcomes (Gallo & Smith, 1998). However, no research (to our knowledge) has attempted to identify how basic personality traits predict judgements of hostile intent (however, for a review of personality's relationship with facets of hostility see Sanz et al., 2010).

There have been some insights into how core personality relates to judgments of hostile intent's downstream components (e.g. blame following perceived transgression, blame-related anger). For example, Bolger (1990) found that following negative events – as reported in a daily diary – those who were high in trait neuroticism were more likely to blame themselves as a coping strategy. However, in terms of assigning blame to the actions

of others, trait agreeableness was reported to moderate the link between accessibility of blame towards the other and subsequent anger (Meier and Robinson, 2004). Here, those with low agreeableness displayed the highest blame accessibility, reflected by a faster choice reaction time on a task containing blameworthy (e.g. “hangover”, “murder”) and non-blameworthy (e.g. “bladder”, “hurricane”) words.

While these studies address how core personality traits may relate to the processes of blame attribution and subsequent anger, they do not address the processes previous literature suggests occur temporally upstream; namely, the encoding and accurate representation of information (Crick & Dodge, 1994) related to judgements on whether events were committed intentionally (Schlenker et al., 1994). Moreover, these previous studies have operationalized core personality traits using models (e.g. Big Three, Big Five) which may not fully capture trait dimensions of key interest to anger aetiology. Specifically, recent work (Ashton & Lee, 2009; Lee & Ashton, 2004; Ashton et al., 2014) suggests that the use of a six-factor model of personality – in particular, the inclusion of trait honesty-humility – provides a more complete view of how individual differences in core personality traits relate to interpersonal outcomes. To address these gaps in the literature, this current work sought to investigate how core personality traits predict factors underlying the likelihood that individuals will judge the actions of others as intentionally hostile, and whether a six-factor model of personality (i.e. HEXACO), compared to a five-factor model (i.e. BFI), accounts for more variance in predictive models.

## Study 1

The aim of Study 1 was to identify how core personality traits relate to the tendency to judge events to be intentionally hostile. We hypothesized that the HEXACO

model of personality, compared to the Big Five model, would provide increased predictive validity of the relationships between core personality and judgements of hostile intent, and that low scores on the traits honesty-humility and agreeableness will be the most highly related traits to judgements of hostile intent. These hypotheses were built upon previous literature investigating similar constructs. For example, compared to other HEXACO traits, honesty-humility has shown the strongest relationship with pro-social attitudes and behaviours within interpersonal social decision making tasks (Zettler, Hilbig, & Heydasch, 2013) and behavioural measures of the belief others will act fairly towards oneself (i.e. trust) in economic games (Thielmann & Hilbig, 2014). Finally, agreeableness has shown the strongest relationship with reactive cooperation and non-retaliation (Hilbig et al., 2013) when individuals are presented with opportunities to transgress against others.

## Methods

### Participants

We recruited 157 participants from Amazon.com's Mechanical Turk (MTurk) system; a population shown to provide reliable data, more closely representative of a general American population than university-student samples (Berinsky, Huber, & Lenz, 2012; Buhrmester, Kwang, & Gosling, 2011; Goodman, Cryder, & Cheema, 2013). Of these, 12 participants were excluded from subsequent analysis due to inappropriate responding (e.g. same response pattern throughout entire dataset). The final sample consisted of 145 participants (72 males) with a mean age of 36.30 (*SD* = 12.32). By race, 77.9% (*n* = 113) of the sample was comprised of individuals identifying as White, 3.4% (*n* = 5) as Hispanic, 2.8% (*n* = 4) as Afro-Caribbean, 2.8% (*n* = 4) as South East Asian, 2.1% (*n* = 3) as

Multiracial, 2.1% (*n* = 3) as Other Asian, 1.4% (*n* = 2) as Chinese, 1.4% (*n* = 2) as Indian, 1.4% (*n* = Pakistani), and 0.7% (*n* = 1) as Japanese.

## Measures

**Personality Traits.** Participants completed both the HEXACO-60 (Ashton & Lee, 2009) and the Big Five Inventory (BFI; John & Srivastava, 1999) measures of personality. Using a five-point Likert scale to rate the degree to which participants agreed with self-descriptive statements, the HEXACO inventory provides scores for honesty-humility ("Having a lot of money is not especially important to me"), emotionality ("I sometimes can't help worrying about little things"), extraversion ("On most days, I feel cheerful and optimistic"), agreeableness ("I tend to be lenient in judging other people"), conscientiousness ("I often push myself very hard when trying to achieve a goal"), and openness to experience ("I'm interested in learning about the history and politics of other countries"). Dimension scores were computed as the mean of item within each sub-scale. Cronbach's alpha for each of the personality measures were all good to excellent: honesty-humility $\alpha = .72$, emotionality $\alpha = .75$, extraversion $\alpha = .86$, agreeableness $\alpha = .79$, conscientiousness $\alpha = .77$, and openness to experience $\alpha = .78$.

Using a five-point Likert scale to rate the degree to which participants agreed with self-descriptive statements, the BFI is designed to be a brief measure (44 items) of the Big-Five personality domains, reflecting the traits neuroticism ("I am someone who is depressed and blue"), extraversion ("I am someone who is talkative"), agreeableness ("I am someone who is helpful and unselfish with others"), conscientiousness ("I am someone who does a thorough job"), and openness to experience ("I am someone who is original, comes up with new ideas"). The mean from each set of items was then calculated to define trait scores. Cronbach's alpha for the each of the personality measures were all good to

excellent: emotional stability α = .90, extraversion α = .90, agreeableness α = .83, conscientiousness α = .88, and openness to experience α = .85.

### Judgments of Hostile Intent

Participants read through 15 short vignettes and were asked to imagine themselves in each of the situations. A total of 15 vignettes (see Appendix A.) were used and covered scenarios that were broadly accidental (e.g. "A friend of yours slips on the ice, knocking you to the ground."), ambiguous (e.g. "You are supposed to meet a new friend for lunch at a restaurant but she/he never shows up."), and intentional (e.g. "Someone jumps in front of you on the grocery line and says, 'I'm in a rush.' You end up dropping some things on the floor.") in nature. These vignettes were presented in pseudo-random order. These vignettes were adapted from stimuli used in related research (Combs et al., 2007; Tremblay & Belchevski, 2004), with language changed to better reflect cultural relevance and situation descriptions shortened where necessary. After each vignette participants were presented with an item measuring perceived intentionality. Each item was rated on a five-point scale identifying how strongly the participant felt about each item (i.e. 1 = completely unintentional, to 5 = completely intentional).

## Results

Descriptive statistics for the personality variables and individual vignettes are presented in Table 3.1 and Table 3.2, respectively. To better understand the psychometric properties of the vignettes we first explored the means of each class (i.e. accidental, ambiguous, intentional) of vignettes followed by a parallel analysis and exploratory factor analysis of the vignettes. As expected, the mean ratings of intent for vignettes in the accidental condition ($M$ = 1.63, $SD$ = .56; range = 1.00-4.20) were lower than the means for vignettes

in the ambiguous condition (*M* = 3.13, *SD* = .73; range = 1.40-5.00), which in turn were lower than the means for vignettes in the intentional condition (*M* = 4.28, *SD* = .55; range = 2.60-5.00). The only exception to this was item eight (ambiguous; *M* = 3.77, *SD* = 1.18) which had a higher mean than the intentional condition's lowest scoring item (vignette one; *M* = 3.17, *SD* = 1.47). Intra-correlations within vignette sets indicate reasonably high positive correlations for accidental (*r* range = .18-.50), ambiguous (*r* range = .20-.36), and intentional (*r* range = .23-.35) vignettes. Inter-correlations demonstrated weak, sometimes negative, or null relationships between accidental and intentional vignettes, while the ambiguous vignettes showed a consistent pattern of relating to both accidental and intentional conditions. Consistent with this observation, correlations between the three conditions' mean scores demonstrated no significant relationship between judgments of intent in the accidental and intentional conditions ($r = .12$, $p = .07$). In contrast, moderate-to-large correlations were noted between the ambiguous and accidental ($r = .49$, $p < .001$) and ambiguous and intentional ($r = .36$, $p < .001$) conditions.

Table 3.1. *Descriptive statistics for study variables*.

| | Mean | SD |
|---|---|---|
| H | 3.45 | .63 |
| E | 3.15 | .66 |
| X | 3.22 | .74 |
| A | 3.28 | .63 |
| C | 3.75 | .57 |
| O | 3.69 | .67 |
| BFI-O | 3.68 | .65 |
| BFI-C | 3.83 | .69 |
| BFI-E | 2.97 | .90 |
| BFI-A | 3.72 | .63 |
| BFI-N | 2.67 | .90 |
| Age | 36.30 | 12.32 |

Note: H = honesty-humility; E = emotionality; X = extraversion; A = agreeableness; C = conscientiousness; O = openness to experience; BFI-O = BFI openness; BFI-C = BFI

conscientiousness; BFI-E = BFI extraversion; BFI-A = BFI agreeableness; BFI-N = BFI neuroticism; *n* = 145.

Table 3.2. *Descriptive statistics for study vignettes.*

| Vignette # | Mean | SD |
|---|---|---|
| *Accidental* | | |
| 2 | 1.15 | .53 |
| 4 | 2.71 | 1.28 |
| 6 | 1.41 | .77 |
| 12 | 1.46 | .80 |
| 14 | 1.43 | .88 |
| *Ambiguous* | | |
| 3 | 2.94 | 1.14 |
| 5 | 3.13 | 1.24 |
| 8 | 3.77 | 1.18 |
| 10 | 2.99 | .96 |
| 13 | 2.80 | 1.11 |
| *Intentional* | | |
| 1 | 3.17 | 1.47 |
| 7 | 4.43 | .90 |
| 9 | 4.71 | .66 |
| 11 | 4.48 | .94 |
| 15 | 4.63 | .78 |

To determine the underlying latent architecture of our items, a parallel analysis (using 1000 repetitions and polychoric correlations as input) was conducted, using the psych (Revelle, 2012) and random.polychor.pa (Presaghi, Desimoni, & Presaghi, 2013) packages for R statistical software (R Core Team, 2013), to guide how many factors to extract for further analyses. By creating a number of correlation matrices of random variables matching the sample size and number of variables in the actual data, parallel analysis adjusts for the effect of sampling error and identifies factors accounting for more variance than parallel factors obtained from random data (Montanelli & Humphreys, 1976;

Turner, 1998). Choosing to extract the number of factors demonstrating higher eigenvalues than 95% of factors generated by the random data, parallel analysis is considered one of the most accurate ways to determine how many factors to retain for factor analysis (Hayton, Allen, & Scarpello, 2004). For transparency, a factor analysis scree plot depicting the use of polychoric correlations and Pearson correlations will be presented below.

The parallel analysis indicated that two factors showed eigenvalues above the 95$^{th}$ percentile of the distribution of eigenvalues derived from the generated random data (see Figure 3.1and Table 3.3). Next, an exploratory factor analysis (using a polychoric correlation matrix, principal axis factoring, and varimax rotation), extracting two factors from the 15 vignettes, was conducted. To summarise the two factor solution (see Table 3.4): the first factor was most heavily loaded on the accidental vignettes (loading range = -0.57- -.79.) and the intentional vignettes (loading range = .61- .65). Exceptions to this general pattern were vignettes 1 and 4 which were most strongly aligned with the second factor. The second factor primarily loaded on the ambiguous vignettes (loading range = .43 - .55). We tentatively interpreted the first latent factor as a sensitivity to the social or contextual cues, contained within the vignettes' text, of intent. We tentatively interpreted the second latent factor as the likelihood to make judgments of hostile intent. Because our interest is in the latent factors underpinning judgments of hostile intent, and the parallel analysis and exploratory factor analysis support the extraction of two factors, individual scores on these two factors were used as outcome variables in all subsequent analyses.

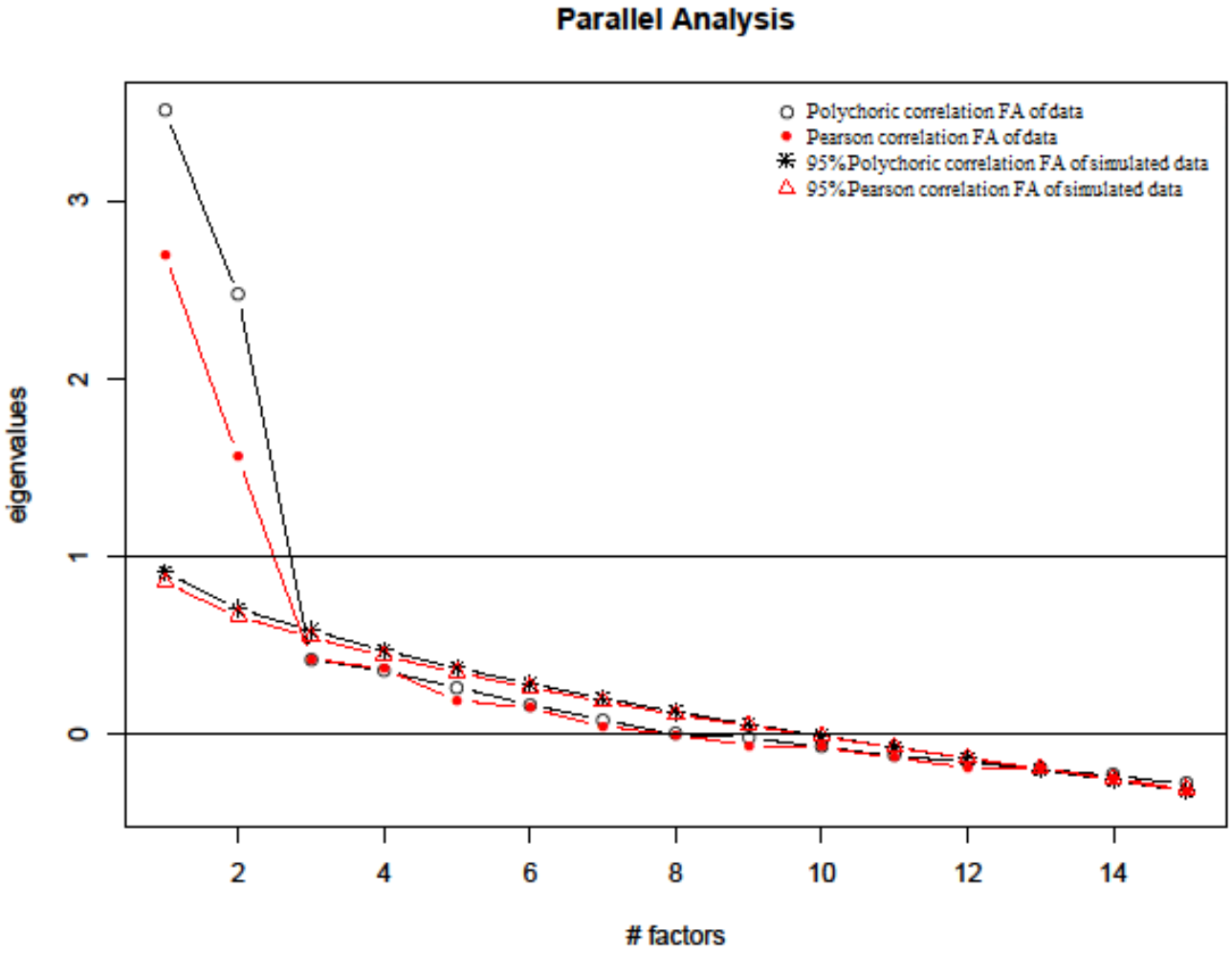


*Figure 3.1.* Scree plot depicting eigenvalues from polychoric-based and Pearson-based parallel analyses of data and 95$^{th}$ percentile of simulated eigenvalues.

Table 3.3. *Variance explained by Exploratory Factor Analysis (varimax rotation) of vignettes.*

| Initial Eigenvalues | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|
| Factor | Total | Total | %Variance | Cumulative% |
| 1 | 3.51 | 3.42 | 23.0 | 23.0 |
| 2 | 2.47 | 2.54 | 17.0 | 40.0 |

Table 3.4. *Pattern matrix for vignettes*.

| | Pattern Matrix | |
|---|---|---|
| Vignette # | Factor 1 | Factor 2 |
| *Accidental* | | |
| 2 | -.79 | .27 |
| 4 | --- | .54 |
| 6 | -.65 | .40 |
| 12 | -.57 | .41 |
| 14 | -.61 | .46 |
| *Ambiguous* | | |
| 3 | --- | .55 |
| 5 | --- | .50 |
| 8 | .25 | .43 |
| 10 | --- | .50 |
| 13 | --- | .53 |
| *Intentional* | | |
| 1 | --- | .35 |
| 7 | .61 | .33 |
| 9 | .64 | .13 |
| 11 | .65 | .28 |
| 15 | .63 | .18 |

Note: --- = absolute value of loading < .10.

Correlation coefficients for each of the HEXACO, Big Five Inventory (BFI), and outcome variables are presented in Table 3.5. Separate linear regression analyses using the

HEXACO and BFI as predictors of participants' scores for the two latent factors are presented in Table 3.6 and Table 3.7. Because previous research has found differences between aspects of hostility and the demographic variables of sex and age (e.g. Barefoot et al., 1993; Buss & Durkee, 1957; Greenglass & Julkunen, 1989) regression analyses were conducted both with and without gender and age included as covariates in order to determine whether any personality traits' relationship with either latent factor was vulnerable to effects related to gender and age.

Table 3.5. *Correlations between dependent, HEXACO, BFI, and demographic variables.*

| Measure | Factor 1 | Factor 2 |
|---|---|---|
| H | .08 | **-.34** |
| E | -.01 | .04 |
| X | .06 | .18* |
| A | .11 | -.03 |
| C | .25** | -.01 |
| O | -.07 | -.09 |
| BFI-O | .05 | -.01 |
| BFI-C | .23** | .11 |
| BFI-E | -.01 | .19* |
| BFI-A | .25** | -.04 |
| BFI-N | -.10 | -.13 |
| Gender | .08 | -.02 |
| Age | .20* | -.09 |

Note: H = honesty-humility; E = emotionality; X = extraversion; A = agreeableness; C = conscientiousness; O = openness to experience; BFI-O = BFI openness; BFI-C = BFI conscientiousness; BFI-E = BFI extraversion; BFI-A = BFI agreeableness; BFI-N = BFI neuroticism; Gender: Male = 1; Gender: Female = 2; Bolded = p<.001; ** p<.01; *p<.05.

Table 3.6. *Linear regression analyses (with standardized beta coefficients) showing effects of HEXACO, with and without demographic variables, on scores in factors 1 and 2.*

| | Factor 1 | | Factor 2 | |
|---|---|---|---|---|
| | without | with | without | with |
| H | .03 | -.01 | **-.34** | **-.34** |
| E | .03 | .01 | .06 | .05 |
| X | -.02 | -.01 | .24** | .23* |
| A | .07 | .06 | .00 | .00 |
| C | .26** | .23* | .00 | .00 |
| O | -.10 | -.08 | -.12 | -.13 |
| Gender | | .07 | | .02 |
| Age | | .14 | | -.04 |
| F | 1.97 | 1.92 | **4.77** | **3.57** |
| $R^2$ | .08 | .10 | **.17** | **.17** |
| Adjusted $R^2$ | .04 | .05 | **.14** | **.13** |

Note: H = honesty-humility; E = emotionality; X = extraversion; A = agreeableness; C = conscientiousness; O = openness to experience; Gender: Male = 1; Gender: Female = 2; Bolded = p<.001; ** p<.01; *p<.05.

Table 3.7. *Linear regression analyses (with standardized beta coefficients) showing effects of BFI, with and without demographic, variables on scores in factors 1 and 2.*

| | Factor 1 | | Factor 2 | |
|---|---|---|---|---|
| | without | with | without | with |
| BFI-O | .04 | .08 | -.07 | -.10 |
| BFI-C | .20 | .17 | .07 | .09 |
| BFI-E | -.10 | -.10 | .20* | .20* |
| BFI-A | .21* | .23* | -.16 | -.18 |
| BFI-N | .09 | .11 | -.12 | -.15 |
| Gender | | .02 | | .01 |
| Age | | .19* | | -.15 |
| F | 2.87* | 2.87* | 2.05 | 1.90 |
| $R^2$ | .09* | .13* | .07 | .08 |
| Adjusted $R^2$ | .06* | .08* | .04 | .04 |

Note: BFI-O = openness; BFI-C = conscientiousness; BFI-E = extraversion; BFI-A = agreeableness; BFI-N = neuroticism; Gender: Male = 1; Gender: Female = 2; Bolded = p<.001; ** p<.01; *p<.05.

Factor 1 was positively correlated with conscientiousness as measured by both the HEXACO ($r$ = .25, p < .01) and BFI ($r$ = .23, p < .01), as well as BFI-agreeableness ($r$ = .25, p < .01) and age ($r$ = .20, p < .05). Factor 2 was negatively correlated with HEXACO honesty-humility ($r$ = -.34, p < .001), and positively correlated with extraversion as measured by both the HEXACO ($r$ = .18, p < .05) and BFI ($r$ = .19, p < .05).

Without gender and age included in the regression model, scores in Factor 1 were predicted by the HEXACO's conscientiousness ($\beta$ = .26, p < .01) and BFI's agreeableness ($\beta$ = .21, p < .05). With gender and age included, regression analyses indicated that scores in Factor 1 were predicted by conscientiousness ($\beta$ = .23, p < .05) when using the HEXACO metric, and by agreeableness ($\beta$ = .23, p < .05) when using the BFI. The predictive validity of core personality was increased for scores in Factor 2, being predicted by HEXACO's (low) honesty-humility ($\beta$ = -.34, p < .001) and extraversion ($\beta$ = .24, p < 05), as well as BFI's extraversion ($\beta$ = .20, p < .05) without gender and age included in the

model. Little change was seen when gender and age were included in the model, with scores in Factor 2 being predicted by HEXACO's (low) honesty-humility ($\beta$ = -.34, p < .001) and extraversion ($\beta$ = .23, p < 05), as well as BFI's extraversion ($\beta$ = .20, p < .05).

## Discussion

This study was, to the best of our knowledge, a novel investigation into how core personality traits (as measured by the HEXACO and Big Five frameworks) relate to judgments of hostile intent. Three key results emerged. Firstly, parallel analysis indicated that two independent latent factors underpinned our hypothetical vignettes. The first factor appeared to capture something akin to "sensitivity to accuracy", with Factor 2 interpreted as tapping the likelihood to interpret hostile acts as intentional. Secondly, linear regression models demonstrated that Factor 1 was predicted by Big Five agreeableness and HEXACO conscientiousness. This apparent discrepancy might reflect the fact that Big Five agreeableness and HEXACO conscientiousness share some common aspects. Factor 2 was predicted by extraversion (HEXACO and Big Five) and HEXACO honesty-humility. Thirdly, the HEXACO framework appears to be marginally more effective at capturing judgements of hostile intent (i.e. Factor 2). Including age and gender as covariates in regression models produced negligible differences in results.

## Study 2

Study 1 provided initial evidence for two underlying factors influencing judgments of intent. Using the HEXACO model of personality, Factor 1 – tentatively interpreted as a sensitivity to accuracy – was predicted by conscientiousness, while Factor 2 – tentatively

interpreted as the likelihood to make judgements of hostile intent – was negatively predicted by honesty-humility and positively by extraversion. In Study 2 we sought to confirm these initial observations and to test candidate mediators in order to better understand the psychological processes linking honesty-humility and extraversion to the factors underlying judgements of hostile intent. Results from Study 1 indicated that the HEXACO metric captured aspects of core personality that the BFI failed to, therefore we opted to use only the HEXACO in Study 2. Since the HEXACO-100 (Lee & Ashton, 2004) provides increased validity over the HEXACO-60, we opted to use the former.

**Mediators of Judgments of Hostile Intent**

Three candidate mediators seemed most plausible: 1) sensitivity to being socially usurped, 2) an inflated sense of self-entitlement, and 3) social projection of one's own characteristics or tendencies. With regards to sensitivity to being socially usurped, we reasoned that individuals who are so inclined would exhibit more pronounced judgements of hostile intent as a pre-emptive strategy in order to mitigate against threats to status. With regards to self-entitlement, we reasoned that individuals with an exaggerated sense of self-importance (i.e. low humility) will consider themselves entitled to unique or special attention, setting the bar so high that others inevitably fail. Evidence suggests that individuals particularly high in both these traits (e.g. narcissists) tend to more frequently perceive themselves as victims in interpersonal interactions (McCullough et al., 2003). In addition, narcissistic traits have demonstrated robust associations with the core dimensions of personality being reported on in Study 1: namely, honesty-humility and extraversion (Lee & Ashton, 2014).

Regarding social projection, we reasoned that individuals' may use their own traits as a barometer for appraising the motivations and intentions of others. As such, individuals with lower trait honesty-humility may be more likely to conclude that an exploitative act

committed by another person was intentional because they themselves would be more likely to be exploitative. Our reasoning here was built upon research demonstrating that social projection, or assumed similarity (for review see Marks & Miller, 1987), may be the mechanism by which some individuals pre-emptively attribute hostile intentions. In support of this perspective, Back and colleagues (2013) found that individuals high in narcissistic-admiration and narcissistic-rivalry projected these traits onto others, viewing others as more aggressive and less trustworthy despite a lack of evidence to support such an interpretation. In addition, Thielmann and Hilbig (2014) found that attributions of trust in others are built upon one's own level of trustworthiness, suggesting that a level of trust in others represents a reasonable proxy of social projection. By itself, the construct of trust has been implicated in judgments of hostile intent by several lines of empirical work. Dodge (2006) argues that, at one of the earliest developmental stages, lack of trust between infants and caregivers fosters schemas that develop into biases towards hostile attributions. Previous evidence indicates that low levels of trust have been shown to relate to notions of being treated unfairly (Sharp, Ha, & Fonagy, 2011) and implausible attributions of ulterior and "sinister" intent (Main, Dahl, & Darke, 2007).

Following the guidelines laid out by Hayes (2013) we felt that our choice of mediation analysis was a sound mathematical model with which to capture the relationship between variables. Personality variables were chosen based upon Study 1 results which indicated their value as predictors. In line with McCrae and Costa's (2008) view of personality, we believe that core traits have downstream consequences on characteristic adaptations (e.g. sensitivity to being socially usurped, sense of self-entitlement, social projection). Hayes (2013) contends that even in the absence of unequivocally established causality – e.g. the data is collected at a single time point and with no experimental manipulation – mediation analysis can still be conducted given a solid theoretical base. For reasons outlined above we believe our theoretical reasoning is justified.

To operationalize these proposed mediators we used the Narcissistic Admiration and Rivalry Questionnaire (NARQ; Back et al., 2013) and a measure of generalized trust (Naef & Schupp, 2009). The NARQ instrument contains two core facets – admiration and rivalry - which tap notions of assertive self-enhancement and antagonistic self-protection, respectively. In order to test whether social projection is a plausible mediating process we also measured generalized trust as a proxy of social projection.

## Methods

### Participants

233 participants (89 males) with a mean age of 36.72 (*SD* = 12.09) were recruited via Amazon.com's Mechanical Turk (MTurk) system. By race, 74.2% (*n* = 173) of the sample was comprised of individuals identifying as White, 10.7% (*n* = 25) as African American, 5.2% (*n* = 12) as Asian, 4.7% (*n* = 11) as Hispanic, 1.3% (*n* = 3) as Native American, and 3.9% (*n* = 9) as Other. Participants completed the HEXACO-100 self-report personality measure, the trust measure, the NARQ, followed by the hypothetical vignettes.

### Measures

**Personality traits.** Participants completed the 100-item HEXACO-PI-R (Lee & Ashton, 2004) personality measure. Because this 100-item metric demonstrates higher internal consistency, and participants were only completing one assessment of core personality (as opposed to the two within Study 1), its use was preferred over its shorter (i.e. 60-item) counterpart. Dimension scores were computed as the mean of items within each sub-scale. Cronbach's alpha for each of the personality measures were all good to excellent: honesty-

humility α = .87, emotionality α = .86, extraversion α = .88, agreeableness α = .89, conscientiousness α = .86, and openness to experience α = .84.

**Trust.** To measure trust, seven items from the German Socio-Economic Panel (SOEP; Naef & Schupp, 2009) were used. Participants were asked: "How much trust do you have in…" 1) your family, 2) neighbours, 3) friends, 4) strangers, and "To what extent do you agree or disagree?"… 5) In general, you can trust people, 6) Nowadays, you can't rely on anybody, and 7) It's better to be cautious before trusting strangers. Possible responses ranged from 1 = Strongly Disagree, to 4 = Strongly Agree. The mean from each set of items was calculated to define the trait scale. Cronbach's alpha for the trust scale was good (α = .75).

**Narcissistic-admiration and narcissistic-rivalry.** Participants completed the self-report Narcissistic Admiration and Rivalry Questionnaire (NARQ; Back et al., 2013). The 18-item metric measured assertive self-enhancement (i.e. grandiose notions of self, inflated sense of uniqueness, charmingness) and antagonistic self-protection (i.e. devaluation of others, a striving for supremacy, aggressiveness). The narcissistic traits were measured by asking participants to rate how strongly they agree that a statement (e.g. "I deserve to be seen as a great personality") applies to them. Possible responses ranged from 1 = Strongly Disagree, to 4 = Strongly Agree. The mean from each set of items was calculated to define trait scales. Cronbach's alphas for narcissistic-admiration and narcissistic-rivalry were excellent (both α = .88).

**Judgements of hostile intent vignettes.** This investigation used identical vignettes as Study 1. See Appendix A. for a full description of the vignettes.

## Results

Descriptive statistics for the HEXACO, NARQ, and trust variables are presented in Table 3.8, followed by descriptive statistics for individual vignettes in Table 3.9. Regarding the vignette classes, the mean ratings of intent in the accidental condition ($M$ = 1.80, $SD$ = .56; range = 1.00-4.20) were lower than the mean rating for vignettes in the ambiguous condition ($M$ = 3.11, $SD$ = .59; range = 1.40-4.60), which were lower than the mean rating for vignettes in the intentional condition ($M$ = 4.22, $SD$ = .62; range = 1.60-5.00) – and similar to the preceding study, the only exception to this was vignette #8 (ambiguous; $M$ = 3.70, $SD$ = 1.01) which had a higher mean than the intentional condition's lowest scoring vignette (vignette #1; $M$ = 3.29, $SD$ = 1.34). Intra-correlations within vignette sets indicated reasonably high positive correlations for accidental ($r$ range = .16-.48), ambiguous ($r$ range = .18-.43), and intentional ($r$ range = .16-.45) vignettes. Inter-correlations demonstrated weak, sometimes negative, or null relationships between accidental and intentional vignettes, while the ambiguous vignettes showed a pattern of relating to both accidental and intentional conditions. Similar to Study 1, correlations between the three conditions' mean scores demonstrated no significant relationship between judgments of intent in the accidental and intentional conditions ($r$ = -.12, p = .07), while moderate correlations existed between the ambiguous and accidental ($r$ = .21, p < .01) and the ambiguous and intentional ($r$ = .45, p < .001) conditions.

Table 3.8. *Descriptive statistics for variables.*

| | Mean | SD |
|---|---|---|
| H | 3.51 | .71 |
| E | 3.25 | .65 |
| X | 3.24 | .67 |
| A | 3.11 | .67 |
| C | 3.77 | .58 |
| O | 3.59 | .61 |
| Admiration | 3.37 | .92 |
| Rivalry | 2.45 | .92 |
| Trust | 2.56 | .44 |
| Age | 36.72 | 12.09 |

Note: H = honesty-humility; E = emotionality; X = extraversion; A = agreeableness; C = conscientiousness; O = openness to experience; *n* = 233.

Table 3.9. *Descriptive statistics for vignettes*.

| Vignette # | Mean | SD |
|---|---|---|
| *Accidental* | | |
| 2 | 1.30 | .76 |
| 4 | 2.70 | 1.05 |
| 6 | 1.63 | .71 |
| 12 | 1.75 | .74 |
| 14 | 1.63 | .78 |
| *Ambiguous* | | |
| 3 | 3.06 | .94 |
| 5 | 3.00 | .96 |
| 8 | 3.70 | 1.01 |
| 10 | 2.93 | .84 |
| 13 | 2.86 | .88 |
| *Intentional* | | |
| 1 | 3.29 | 1.34 |
| 7 | 4.25 | .90 |
| 9 | 4.64 | .73 |
| 11 | 4.31 | .92 |
| 15 | 4.59 | .87 |

As with Study 1, we examined the psychometric properties of the vignettes through parallel analysis and factor analysis. Parallel analysis – using 1000 repetitions and polychoric correlations as input – again indicated that two factors showed eigenvalues above the 95$^{th}$ percentile of the distribution of eigenvalues derived from the generated random data (see Figure 3.2 and Table 3.10). Next, an exploratory factor analysis (using a polychoric correlation matrix, principle axis factoring, and varimax rotation) extracting two factors from the 15 vignettes, was conducted. Results of the factor analysis largely mirrored results from Study 1, and indicated that two distinct latent factors were present. To summarise the two factor solution (see Table 3.11): the first factor was most heavily loaded on the accidental (loading range = 0.57 - 0.80) and intentional (loading range = -0.41 - -0.63) vignettes. Exceptions to this general pattern were vignettes 1 and 4 which were most strongly aligned with the second factor. The second factor primarily loaded on the ambiguous vignettes (loading range = 0.40 – 0.58). These factors were essentially identical to the two factors identified in Study 1 and so we interpret them in the same way: Factor 1 tapping a sensitivity to accuracy and Factor 2 tapping the likelihood to judge a hostile act as intentional.

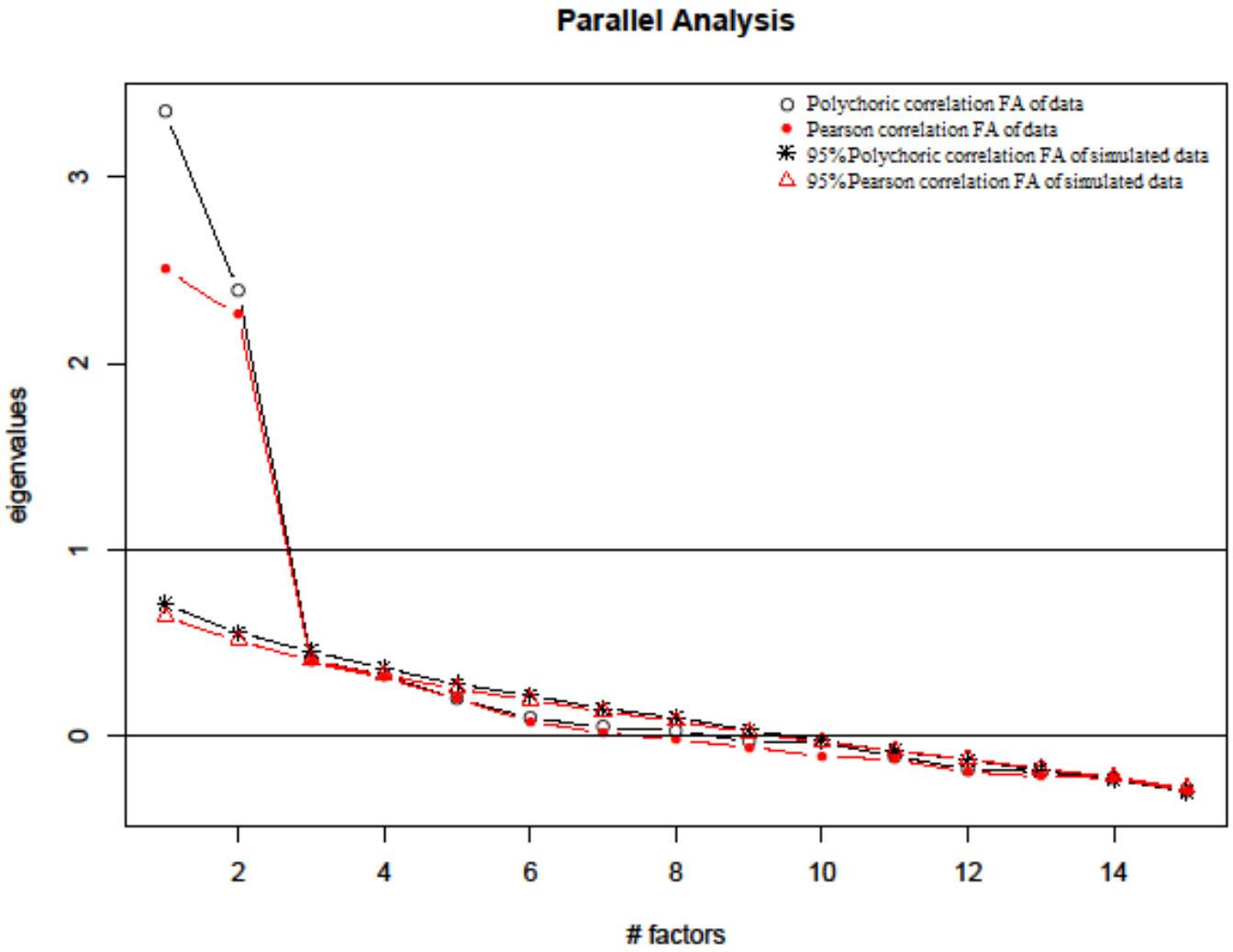


*Figure 3.2.* Scree plot depicting eigenvalues from polychoric-based and Pearson-based parallel analyses of data and 95$^{th}$ percentile of simulated eigenvalues.

Table 3.10. *Variance explained by Exploratory Factor Analysis (varimax rotation) of vignettes.*

| Initial Eigenvalues | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|
| Factor | Total | Total | %Variance | Cumulative% |
| 1 | 3.35 | 3.30 | 22.0 | 22.0 |
| 2 | 2.39 | 2.45 | 16.3 | 38.3 |

Table 3.11. *Pattern matrix for vignettes.*

| | Pattern Matrix | |
|---|---|---|
| Vignette # | Factor 1 | Factor 2 |
| *Accidental* | | |
| 2 | .80 | --- |
| 4 | .19 | .31 |
| 6 | .72 | .41 |
| 12 | .57 | .22 |
| 14 | .66 | .23 |
| *Ambiguous* | | |
| 3 | --- | .45 |
| 5 | --- | .44 |
| 8 | -.24 | .40 |
| 10 | --- | .57 |
| 13 | .10 | .58 |
| *Intentional* | | |
| 1 | --- | .44 |
| 7 | -.41 | .56 |
| 9 | -.62 | .31 |
| 11 | -.57 | .37 |
| 15 | -.63 | .37 |

Note: --- = absolute value of loading < .10.

Correlation coefficients for each of the HEXACO traits, proposed mediators, and outcome variables are presented in Table 3.12. For reasons outlined in Study 1, regression analyses were run both with (see Table 3.13) and without (see Table 3.14) gender and age included as covariates. A hierarchical linear regression analysis of personality and demographic (Step 1), and proposed mediator effects (Step 2) on judgments of hostile intent within the vignette conditions is presented in Table 3.13. During the regression analyses it was observed that without gender and age being included as covariates, honesty-humility's hypothesised association with participants' scores in Factor 2 was a statistically significant and in the expected direction; including gender and age as covariates produced a small change in Beta and removed the statistical significance (i.e. $p = .13$). Because honesty-humility's relationship with scores in Factor 2 was in the anticipated direction, and we believed this relationship to be nonetheless meaningful, mediation analysis was conducted.

Table 3.12. *Correlations among dependent, HEXACO, NARQ, and trust variables.*

| Measure | Factor 1 | Factor 2 | H | E | X | A | C | O | Admiration | Rivalry | Trust | Gender |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | **-.27** | -.10 | | | | | | | | | | |
| E | -.11 | -.06 | .08 | | | | | | | | | |
| X | .03 | .01 | -.03 | **-.22** | | | | | | | | |
| A | .07 | -.04 | **.33** | -.19** | **.32** | | | | | | | |
| C | **-.27** | .15* | **.24** | -.16* | **.29** | **.25** | | | | | | |
| O | -.19** | .02 | .06 | -.06 | **.27** | **.29** | **.30** | | | | | |
| Admiration | **.28** | .21** | **-.46** | -.18** | **.52** | .05 | .03 | .09 | | | | |
| Rivalry | **.43** | .09 | **-.65** | -.09 | -.14* | **-.40** | **-.40** | **-.30** | **.38** | | | |
| Trust | -.05 | **-.29** | **.24** | -.05 | **.35** | **.40** | .09 | .15* | .01 | **-.23** | | |
| Gender | -.19** | -.12 | **.35** | **.43** | -.10 | .07 | .14* | .06 | -.17* | **-.33** | .05 | |
| Age | -.21** | -.01 | **.25** | -.17** | .14* | .18** | .10 | .08 | -.16* | -.21** | .14* | .07 |

Note: H = honesty-humility; E = emotionality; X = extraversion; A = agreeableness; C = conscientiousness; O = openness to experience; Gender: Male = 1; Gender: Female = 2; Bolded = p<.001; ** p<.01; *p<.05.

Table 3.13. *Linear regression analysis (with standardized beta coefficients) showing Study 2 personality, demographic, and proposed mediator effects on the factors underlying judgments of hostile intent.*

| | Factor 1 | | Factor 2 | |
|---|---|---|---|---|
| | Step 1 | Step 2 | Step 1 | Step 2 |
| H | .22** | .02 | -.12 | .09 |
| E | .11 | .06 | .01 | .06 |
| X | -.06 | -.06 | -.06 | -.12 |
| A | **-.26** | **-.32** | -.03 | .04 |
| C | .23** | .17* | .21** | .19* |
| O | .19** | .12 | .02 | .04 |
| Gender | .00 | .01 | -.14 | -.17* |
| Age | .19** | .16** | .00 | .05 |
| Admiration | | -.08 | | .30** |
| Rivalry | | **-.38** | | .03 |
| Trust | | .07 | | **-.31** |
| F | **8.18** | **8.91** | 1.84 | **4.90** |
| $R^2$ | **.23** | **.31** | .06 | **.20** |
| Adjusted $R^2$ | **.20** | **.28** | .03 | **.16** |

Note: H = honesty-humility; E = emotionality; X = extraversion; A = agreeableness; C = conscientiousness; O = openness to experience; Gender: Male = 1; Gender: Female = 2; Bolded = p<.001; ** p<.01; *p<.05.

Table 3.14. *Linear regression analysis (with standardized beta coefficients) showing Study 2 personality and proposed mediator effects on the factors underlying judgments of hostile intent, without gender and age included as covariates.*

| | Factor 1 | | Factor 2 | |
|---|---|---|---|---|
| | Step 1 | Step 2 | Step 1 | Step 2 |
| H | **.27** | .00 | -.15* | .05 |
| E | .08 | .03 | -.05 | -.02 |
| X | -.04 | -.02 | -.05 | -.09 |
| A | **-.25** | **-.32** | -.04 | .05 |
| C | .23** | .16* | .19* | .16* |
| O | .20** | .13* | .02 | .04 |
| Admiration | | -.12 | | .27** |
| Rivalry | | **-.38** | | .05 |
| Trust | | .07 | | **-.31** |
| F | **9.15** | **9.88** | 1.93 | **5.32** |
| $R^2$ | **.20** | **.29** | .05 | **.18** |
| Adjusted $R^2$ | **.18** | **.26** | .02 | **.15** |

Note: H = honesty-humility; E = emotionality; X = extraversion; A = agreeableness; C = conscientiousness; O = openness to experience; Bolded = p<.001; ** p<.01; *p<.05.

Factor 1 was negatively correlated with honesty-humility ($r$ = -.27, p < .001), conscientiousness ($r$ = -.27, p < .001), openness ($r$ = .-.19, p < .01), gender ($r$ = -.19, p < .01) and age ($r$ = -.21, p < .01), and positively correlated with narcissistic-admiration ($r$ = .28, p < .001) and narcissistic-rivalry ($r$ = .43, p < .001) . Factor 2 was positively correlated with conscientiousness ($r$ = .15, p < .05) and narcissistic-admiration ($r$ = .21, p < .01), and negatively correlated with trust ($r$ = -.29, p < .001).

Regression modelling (Step 1) showed that Factor 1 was predicted by honesty-humility ($\beta$ = .22, p < .01), (low) agreeableness ($\beta$ = -.26, p < .001), conscientiousness ($\beta$ = .23, p < .01), openness to experience ($\beta$ = .19, p < .01), and age ($\beta$ = .19, p < .01). With the proposed mediators included in the regression model (Step 2), Factor 1 was predicted by

(low) agreeableness ($\beta$ = -.32, p < .001), conscientiousness ($\beta$ = .17, p < .05), age ($\beta$ = .16, p < .01), and (low) narcissistic-rivalry ($\beta$ = -.38, p < .001. When gender and age were omitted as covariates in the regression models, a notable difference was seen in openness to experience's ability to predict scores in Factor 1 ($\beta$ = .13, p < .05) when controlling for the effects of the proposed mediators.

Regression modelling (Step 1) showed that Factor 2 was predicted by conscientiousness ($\beta$ = .21, p < .01). With the proposed mediators included in the regression model (Step 2), Factor 2 was predicted by conscientiousness ($\beta$ = .19, p < .05), gender ($\beta$ = -.17), narcissistic-admiration ($\beta$ = .30, p < .01), and (low) trust ($\beta$ = -.31, p < .001). When gender and age were omitted as covariates in the regression models, a notable difference was seen in honesty-humility's ability to predict scores in Factor 2 ($\beta$ = -.15, p < .05) when not controlling for the effects of the proposed mediators.

Next, in accordance with our a priori hypotheses, we sought to test whether our proposed mediators of narcissistic admiration, narcissistic rivalry, and generalized trust significantly influenced the relationships between honesty-humility and scores in Factor 2. Meditation analysis was conducted using the Process macros for SPSS (http://www.processmacro.org/), in the method described by Hayes (2013) and included other HEXACO factors, sex, and age as covariates (see Table 3.15).

Table 3.15. *Study 2 mediation analysis (with unstandardized coefficients) of honesty-humility's pathway towards scores on Factor 2.*

| | Coefficient | *SE* | *t* | *ρ* |
|---|---|---|---|---|
| Parallel mediation analysis | | | | |
| Independent variable to mediators (*a* paths) | | | | |
| Admiration | -.57 | .07 | -7.72 | **.001** |
| Rivalry | -.66 | .07 | -9.41 | **.001** |
| Trust | .11 | .04 | 2.57 | .011* |
| Direct effect of mediators on dependent variable (*b* paths) | | | | |
| Admiration | .29 | .09 | 3.31 | **.001** |
| Rivalry | .03 | .09 | 0.31 | .758 |
| Trust | -.63 | .14 | -4.37 | **.001** |
| Direct effect of independent variable on dependent variable (*c'* path) | | | | |
| H | .11 | .11 | 0.97 | .331 |
| Indirect effect of independent variable on dependent variable (*ab* paths) | | | LLCI | ULCI |
| Admiration | -.19 | .06 | -.300 | -.084 |
| Rivalry | -.02 | .07 | -.166 | .122 |
| Trust | -.08 | .04 | -.182 | -.008 |

Note: H = honesty-humility; LLCI = lower level confidence interval; ULCI = upper level confidence interval; Bolded = p<.001; ** p<.01; *p<.05.

This analysis revealed that honesty-humility's pathway to participants' scores within the second latent factor was significantly mediated by two of the proposed mediators: narcissistic-admiration and generalized trust. As can be seen in Table 3.15 and Figure 3.3, participants' scores on honesty-humility predicted scores on measures of narcissistic-admiration ($a_1$ = -.57, p < .001), narcissistic-rivalry ($a_2$ = -.66, p < .001), and generalized trust ($a_3$ = .11, p < .05). Bias-corrected bootstrap confidence intervals, based on 1,000 bootstrap samples, for the indirect effect of honesty-humility through narcissistic-admiration ($a_1b_1$ = -.19), narcissistic-rivalry ($a_2b_2$ = -.02), and generalized trust ($a_3b_3$ = -.08) indicated that those related to narcissistic-admiration (-.300 - -.084) and generalized trust (-

.182 - -.008) were entirely below zero. Furthermore, there was no evidence that honesty-humility significantly influenced participants' scores on Factor 2 independent of its effect through the mediators ($c'$ = .11, p = .331).

Because conscientiousness was seen to predict scores in factor two, a post hoc analysis was conducted to examine whether any of the proposed mediators had a significant effect of conscientiousness' pathway. However, this analysis did not reveal any significant effects related to the mediators and so is not reported on further here.

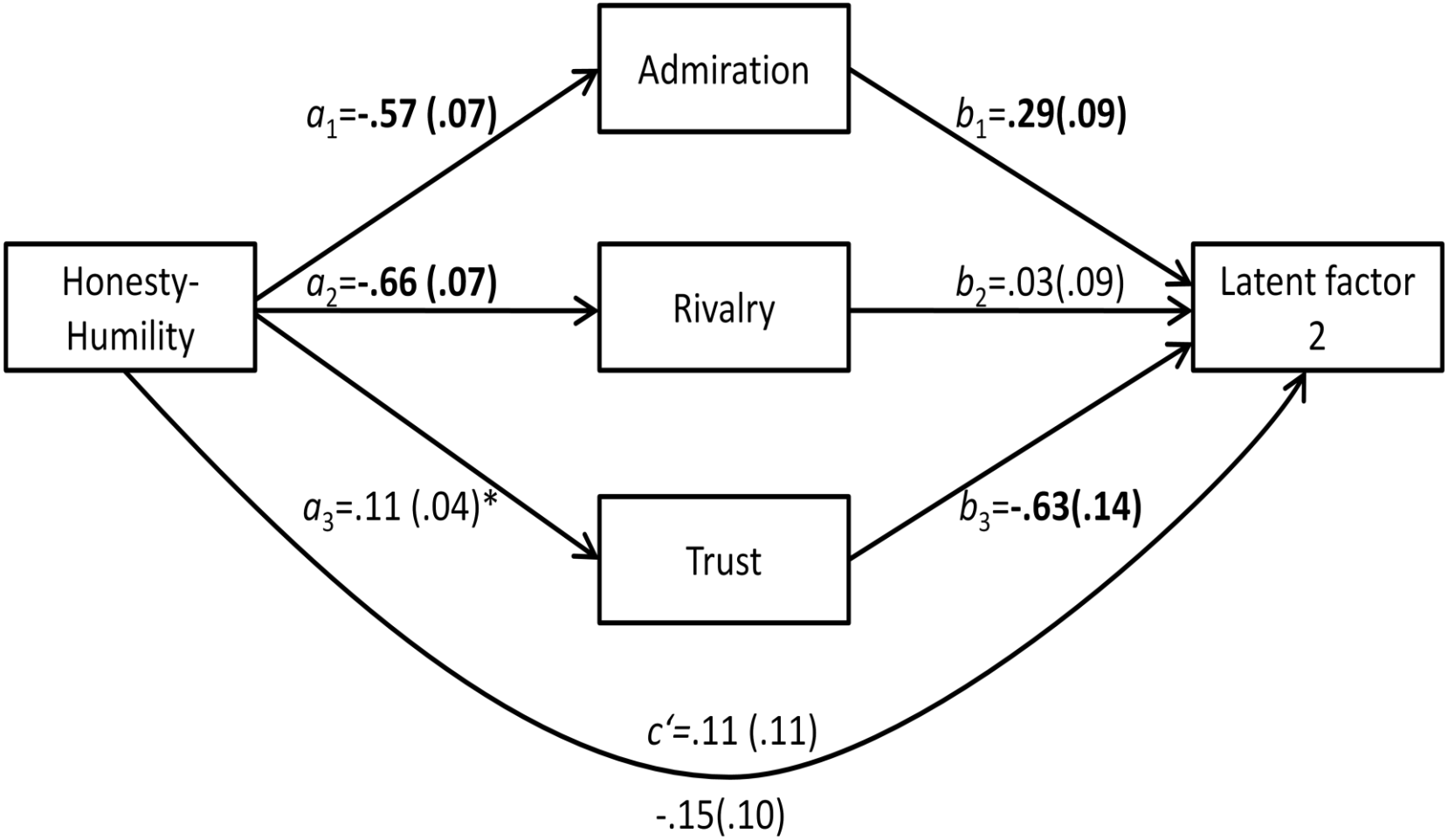


*Figure 3.3.* Relationships between Study 2 predictor, mediating, and outcome variables. Note: Bolded = p<.001; ** p<.01; *p<.05.

## Discussion

It was expected that honesty-humility and extraversion would demonstrate effects similar to those seen in Study 1, and that these effects would be mediated by one or more higher-level cognitive processes – i.e. narcissistic-admiration, narcissistic-rivalry, and generalized trust. In Study 2, we found no evidence for extraversion's role on the pathway towards either identified latent factor. Results from this study indicated that the personality traits honesty-humility, agreeableness, conscientiousness, and openness to experience predicted participants' scores in Factor 1, while scores in Factor 2 were predicted by only conscientiousness. However, as described above, when gender and age were removed as covariates in the regression models, the relationship between honesty-humility and scores in Factor 2 closely resembled result from Study 1 – for this reason, a subsequent mediation analysis was conducted to further examine this relationship.

Including the proposed mediators of narcissistic-admiration, narcissistic-rivalry, and generalized trust in the regression models eliminated the statistically significant effects related to honesty-humility and openness to experience, while effects related to conscientiousness and agreeableness remained. Regarding the proposed mediators, narcissistic-rivalry was an inverse predictor of participants' scores in Factor 1, such that high scores in the former predicted low scores in the latter. Similarly, generalized trust was seen to be an inverse predictor of participants' scores in Factor 2. Narcissistic-admiration was seen to predict participants' scores in Factor 2, such that high scores in one related to higher scores in the other. Mediation analysis of honesty-humility's pathway towards scores in Factor 2 indicated that narcissistic-admiration and generalized trust both affected the relationship, such that those high in the former or low in the latter were more likely to rate situations described within the vignettes as intentional.

The relationship we observed between agreeableness and participants' scores in Factor 1 was somewhat surprising. Considering the positive relationship agreeableness has with prosocial behaviours (Lee & Ashton, 2005), it would be expected that the relationship seen here would align in the same direction as honesty-humility and conscientiousness. With no known literature relating higher levels of the trait agreeableness with judgments of hostile intent, anger, or aggression we are at a loss as to why this investigation found evidence for higher levels of agreeableness predicting a lack of sensitivity to cues of attribution contained within the text. To that end, further work should be conducted in an attempt to identify the nature of agreeableness' relationship with the latent factors underlying judgments of hostile intent.

Conscientiousness was shown to be a positive predictor of scores in both Factor 1 and Factor 2. For reasons similar to Study 1, results related to conscientiousness and Factor 1 makes sense when considering the behavioural descriptors that define this trait. Individuals high in this trait tend to deliberate more when making decisions (Lee & Ashton, 2004) suggesting that individuals may devote more cognitive effort evaluating the hypothetical scenario, while striving for an accurate assessment of the situation. The relationship seen between conscientiousness and Factor 2 also makes sense in light of the social projection and assumed similarity literature (Marks & Miller, 1987). As conscientiousness is partly defined by careful and precise behaviour (Ashton & Lee, 2007), those high in this trait may assume others are equally as deliberate. Assuming that the other is deliberate in their actions may encourage an individual to assume that events were intentionally hostile.

Curiously, participants' openness to experience scores predicted scores in Factor 1. With a lack of (to the best of our knowledge) any prior evidence to suggest or support a relationship between openness to experience and factors underlying attributions of hostile

intent, we refrain from interpreting this association and suggest that further work be conducted in an attempt to identify the nature of this relationship.

## General Discussion

Study 1 provided the first evidence, to our knowledge, of low-level personality's role as a predictor of the latent processes underlying attributions of hostile intent. Study 2 aimed to replicate these findings, while also investigating potential mediator effects on the pathway towards the two latent factors identified. Results in Study 1 indicated that (low) honesty-humility and extraversion (as measured by the HEXACO) were predictors of participants' scores in Factor 2; however, these results failed to replicate in Study 2 – except in the case of honesty-humility's relationship when gender and age were not included as covariates in the regression model. Several lines of research outlined above support roles for honesty-humility and extraversion in the pathway towards judgments of hostile intent. However, lacking a clear explanation as to why these relationships were not seen, we can only assert that further work is needed to more accurately describe the roles of honesty-humility and extraversion in judgments of hostile intent.

Curiously, across studies agreeableness demonstrated effects that were in contrast to each other. In Study 1 BFI-agreeableness predicted scores in Factor 1, and despite a strong correlation between HEXACO and BFI metrics of agreeableness (see Appendix B.; $r = .74$, $p < .001$), only the latter was shown to predict scores in Factor 1. While the positive relationship between scores in agreeableness and Factor 1 may seem somewhat intuitive and straightforward, results from Study 2 contrasted this finding in that agreeableness (as measured by the HEXACO) was inversely related to scores in Factor 1. Without a clear explanation as to why effects in opposite directions were seen, we can only

assert that further work attempt to clarify the nature of the relationship between agreeableness and scores in Factor 1.

Additional results warranting further investigation relate to openness to experience. In particular, its role as a predictor of Factor 1 scores in Study 2 was unexpected. This relationship was not seen in Study 1, and was no longer statistically significant in Study 2 after the potential mediators were added to the regression model. Without a reasonable explanation as to why these particular results was seen, we limit our attempt to explain and justify it, and suggest that future work should seek to clarify the nature, if any, of this relationship.

Conscientiousness was shown to positively predict latent Factor 1 in Study 1, and both latent factors in Study 2. As stated above, the former relationship is likely due to an increase in task diligence. The relationship conscientiousness shares with Factor 2 was unexpected, yet not entirely surprising. In line with the literature on assumed similarity (for review see Marks & Miller, 1987), an individual high in conscientiousness is likely to assume others share their high level of prudence and diligence in social situations. While further work should seek to more thoroughly identify the relationship conscientiousness has with Factor 2, we present evidence of its consistent relationship with latent Factor 1.

After observing the relationships between factors underlying judgments of hostile intent and both (low) honesty-humility and extraversion in Study 1, we proposed several potential constructs built upon previous research that may have been mediating these pathways. Because no direct effect was seen in relation to extraversion, mediation analysis was only performed looking at the relationship between honesty-humility and latent Factor 2. A parallel mediation analysis was conducted and found that an inflated sense of self-entitlement – captured by the narcissistic-admiration metric – and social projection of one's own traits onto others – captured by the generalized trust metric – were significant

mediators of honesty-humility's influence on particpants' scores in Factor 2. More simply stated, higher scores in narcissistic-admiration and lower scores in generalized trust influenced honesty-humility's pathway towards Factor 2 such that individuals were more likely to rate the vignettes as intentional.

Exploratory factor analysis conducted on the hypothetical vignettes used in these studies revealed two distinct factors being measured by the judgments of hostile intent metric. These results suggest that independent pathways leading to judgments of hostile intent exist and are worth further exploration. While we remain hesitant, pending further work, to definitively label these factors, we tentatively interpreted Factor 1 as a sensitivity to the cues of attribution contained within the stimuli, and Factor 2 as tapping the likelihood to judge a hostile act as intentional.

Regarding Factor 1, some support for our tentative interpretation can be found by examining the content of the items defining Factor 1 – i.e. the accidental and intentional vignettes. These vignettes contained depictions of events that vary locus of control from low to high, respectively. For example, across both studies Factor 1's highest loading accidental vignette (#2) describes a situation where a friend slips on the ice – an event which, outside of additional knowledge, is almost certainly out of the friend's control. Locus of control is a crucial consideration when making attributions of intent (Weiner, 2000). Individuals scoring higher in Factor 1 appear more attuned to identifying and rating attributions of intent on the subtle textual cues, contained within the vignettes, providing information as to the potential transgressor's locus of control.

Regarding Factor 2, support for our tentative interpretation could be found by examining the defining items which describe a potential transgressor's lack of consideration or social gaffe towards the individual. For example, this factor's highest loading item in Study 1(vignette #3) describes an event where a co-worker fails to

acknowledge or greet the reader. Similarly, the highest loading item from Study 2 (vignette # 13) describes a situation where a friend fails to return a phone call after being asked. Moreover, the accidental and intentional vignettes that more heavily load onto this factor, rather than Factor 1, depict events in which the potential transgressor demonstrates an apparent lack of social consideration towards the reader. Individuals scoring higher in Factor 2 were more likely to rate situations depicting deliberate lack of consideration towards the reader as more intentional.

Results from both studies align with previous work emphasizing honesty-humility and agreeableness as independent constructs (Ashton et al., 2014). These results provide some evidence of honesty-humility's role in an individual's reporting of judgments of intent, supporting Ashton and colleagues' (2014) claim that honesty-humility influences how an individual perceives an interpersonal event. However, the discrepancy in results between studies – with one effect even in contrast between investigations – suggests that judgments of hostile intent may be best predicted by higher-level constructs such as Study 2's proposed mediators.

Concerning the effect of mediation reported here, a high level of narcissistic-admiration suggests that one feels entitled to special treatment, while low generalized trust in others suggests that an individual is projecting their own untrustworthiness – i.e. likelihood to exploit – onto others (Hilbig, 2014). Belief that one is entitled to special treatment may influence an individual to assume that they are so noteworthy in any given social situation that they find it hard to believe that any transgression was committed without hostile intent – e.g. as the person most entitled to recognition and attention, it may seem impossible that the other did not noticed their presence and subsequently spilled a drink, not said hello in passing, missed the appointment, etc. Results from Study 2 indicated that on the pathway towards judgements of hostile intent, narcissistic-admiration

demonstrated both a direct effect and a mediation effect on honesty-humility's influence. Thus, narcissistic-admiration appears to be a reasonable predictor of judgements of hostile intent. Social projection of one's own aversive traits onto others has been noted by prior investigations (e.g. Back et al., 2013), and influences the individual most likely to exploit others to believe that others are out to exploit them, despite little or no evidence to support such a belief. Results presented in Study 2 indicated that higher scores on the metric of generalized trust – as a proxy of social projection – demonstrated both a direct effect, predicting scores in Factor 2, and a mediation effect on honesty-humility's influence towards scores in Factor 2. In other words, results indicated that social projection of one's own untrustworthiness onto others demonstrates both a direct and indirect effect influencing the likelihood that one judges events to be intentionally hostile. A sensitivity to being socially usurped – captured by the narcissistic-rivalry metric – was the only proposed mediator that demonstrated a direct effect predicting scores within Factor 1. Scores on the narcissistic-rivalry metric were not related to participants' scores in Factor 2, and demonstrated no significant mediation effect.

A limitation of this study may have been the use of single-reporter methodology to collect both the personality and judgments of intent data. In their summary of frequent method biases Podsakoff and colleagues (2003) consider artefactual effects related to common source or rater to be important considerations when collecting data. With the personality measures used here containing statements about thoughts or attitudes, it is possible that participants attempted to maintain consistency between the personality metrics' items – specifically, the ones that reflected attitudes or thoughts towards others – and the explicit ratings of intent, or that social desirability to not appear overly suspicious of the motives of others influenced participants' responses. Use of an implicit measure of judgments of intent would address both of these potential biases, allowing less opportunity for participants to report answers under the influence of factors such as social desirability

or consistency motif (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Using only one measure of personality in Study 2 was also a limitation. Within Study 1, the BFI metric of core personality was a stronger predictor of participants' scores in Factor 1, somewhat challenging our expectation that the HEXACO would be a more robust predictor of factors underlying judgments of hostile intent. Another limitation of the measure was revealed by the less than ideal Cronbach's alpha scores for each of the vignette conditions. Future work should focus on development of a scale, measuring judgments of intent, with high internal consistency.

A caveat of this research relates to the mediation analysis. As stated above, it was only after gender and age were omitted as covariates in the regression model that honesty-humility predicted scores in Factor 2, within Study 2. We chose to proceed with the mediation analysis because the effect was similar in size and direction as that which was seen in Study 1, and we believed this relationship to be meaningful. Therefore, we conducted the mediation analysis, but stress that results should be tentatively interpreted, pending replication or further investigation.

The overall findings here provide evidence for two latent factors influencing judgments of intent, demonstrate the importance of differentiating between the personality traits honesty-humility and agreeableness, and add an understanding of the mediating effects an inflated sense of self-entitlement and social projection have on the core personality trait honesty-humility. Using the system model laid out by McCrae and Costa (1999), these results provide evidence of a characteristic adaptation (e.g. narcissistic-admiration) mediating a basic tendency's (i.e. honesty-humility) pathway towards at least one factor underlying an objective biography (i.e. a bias towards judgments of intentionality within scenarios lacking cues of deliberate intent).

# Chapter 4

# The role of gray matter volume in the experience of anger amongst healthy participants

## Introduction

How neural architecture relates to factors influencing interpersonal behaviour is of increasing interest to researchers. One such influential factor under investigation here is the affective experience of anger. While evidence of a relationship between disruptions to brain integrity and anger/aggression is not a new phenomenon, the use of modern neuroimaging methods has allowed for greater understanding of how distinct regions of the brain affect the experience and expression of anger. Anger then, in turn, predicts numerous implicit (i.e. cognitive) and explicit (i.e. behavioural) outcomes (for review see, Wilkowski & Robinson, 2010). While these investigations have largely focused on how levels of functioning within key brain regions correlate with outcomes such as affective anger, less attention has been given to how volumetric differences in the brain's gray matter (GM) may relate. Containing the highest density of intracranial neurons, GM is considered to be where computational elements of cognition occur (Miller, Alston, & Corsellis, 1980), with GM volume correlating with performance across multiple cognitive tasks (Gur et al., 1999). Therefore, identifying correlations between regional volumetric difference in GM and trait anger is a theoretically relevant and logically driven investigation.

### Neural bases of anger: An overview

Although little work has directly addressed GM correlates of anger (but see Reuter et al., 2009), specific brain regions have been implicated using other neuroscience techniques. Using animal models, localized brain stimulation and lesion studies have provided

consistent evidence of a circuit underpinning the affective experience of anger (Panksepp, 1998, p. 196; 2010) This circuit includes areas associated with general states of arousal – i.e. the periaqueductal gray (PAG), hypothalamus, amygdala – as well as areas responsible for inhibitory control of cognitive processes – i.e. medial and lateral frontal cortices.

Evidence for similar neural underpinnings in humans has been supported by functional neuroimaging investigations. Next, we will outline findings (see Table 4.1) from these investigations, making note of those instances where decreased activation was reported in particular regions. One of the earlier methods of neuroimaging used to investigate anger was positron emission tomography (PET). Using this method, Damasio and colleagues (2000) asked a sample of adults ($n$ = 41) to self-induce anger and reported activation at the left pons, bilateral midbrain around the PAG, left hypothalamus, bilateral insula, bilateral anterior cingulate (both increased and decreased depending on coordinates within the structure), bilateral posterior cingulate (both increased and decreased depending on coordinates within the structure), bilateral secondary somatosensory cortex, and right orbitofrontal cortex. In a sample of adult males ($n$ = 8), Dougherty and colleagues (1999) reported that an angry response to hypothetical vignettes was related to increased activation in the left lateral orbitofrontal cortex, right rostral anterior cingulate, bilateral anterior temporal pole, left precentral gyrus, left medial frontal lobe, and left cerebellum. Kimbrell and colleagues (1999) reported that when adult participants ($n$ = 18) self-induced anger paired with viewing images of angry faces activation was seen in the right thalamus, bilateral superior temporal frontal cortex, left medial frontal gyrus, (decreased) right superior temporal gyrus, (decreased) right inferior parietal lobe, and (decreased) middle frontal gyrus.

A more recent neuroimaging method used to investigate anger is functional magnetic resonance imaging (fMRI). Using fMRI Satpute and colleagues (2013) reported

decreased activation in the left PAG while participants (*n* = 11) self-reported their affective response to viewing anger-inducing images. In a student sample (*n* = 28) Denson and colleagues (2009) verbally provoked participants and reported activation in the bilateral anterior cingulate, bilateral insula, bilateral posterior cingulate, bilateral medial frontal gyrus, bilateral middle frontal gyrus, bilateral hippocampus, and left thalamus. Also in a student sample (*n* = 21), Fabiansson and colleagues (2012) asked participants to recall an anger-related autobiographical memory and reported activation in right medial orbital gyrus, right anterior orbital gyrus, right posterior gyrus, right inferior frontal gyrus, right insula, right amygdala, right putamen, right caudate head, right precentral gyrus, right thalamus, right lingual gyrus, and right lateral globus pallidus. In a sample of adult males (*n* = 27), Alia-Klein and colleagues (2009) verbally provoked participants and reported activation related to anger-reactivity in the left amygdala, and decreased activation related to anger-control in the left anterior thalamus. Using a sample of male students separated into high (*n* = 21) and low (*n* = 18) aggression contrasts, Pawliczek and colleagues (2013) reported anger related activation in the left dorsal anterior cingulate, cerebellum, right thalamus, left amygdala, left inferior parietal lobule, left lateral globus pallidus, right parahippocampal gyrus, right ventrolateral prefrontal cortex, left claustrum, and left cingulate gyrus. Using adult method actors (*n* = 10), Kassam and colleagues (2013) reported that when asked to become angry participants displayed activation in the right caudate nucleus, right precentral gyrus, and left anterior cingulate. In a sample of students (*n* = 32), de Greck and colleagues (2012) reported that self-induced anger, while viewing angry familiar faces, was related to activation in the left inferior frontal gyrus, right middle frontal gyrus, bilateral supplementary motor area, left anterior insula, left putamen, and occipital cortex.

While less attention has been paid to the neuroanatomical correlates of anger (and related constructs), there have been some findings related to brain regions' volume or

integrity. Analyzing manually segmented MRI anatomical images of adult males (*n* = 56), Pardini and colleagues (2014) reported reduced GM bilaterally in the amygdala related to aggression and psychopathic traits. Using computerized tomography and a sample of male veterans with traumatic brain injury (*n* = 279), Grafman and colleagues (1996) reported that lesions to the ventromedial prefrontal cortex were related to increased anger and aggression. Finally, using voxel-based morphometry (VBM) and a sample of adults (*n* = 47) Reuter and colleagues (2009) reported that trait-anger correlated with GM volume in the left midbrain, right caudate, (negatively) left amygdala parahippocampal gyrus, (negatively) left superior frontal gyrus, (negatively) left precuneus, and (negatively) left temporal lobe. In sum then, amygdala, portions of medial frontal cortex, PAG, insula, anterior cingulate, middle and inferior frontal gyrus, and hypothalamus appear to represent core structures underpinning the expression of anger. The anatomical and functional findings summarised above are detailed in Table 4.1.

Table 4.1. *Authors, coordinates, regions, hemisphere, and basic study paradigms detailed for studies related to neuroimaging of anger.*

| Authors | MNI-X | MNI-Y | MNI-Z | Reported ROI | Hemisphere | Paradigm |
|---|---|---|---|---|---|---|
| Fabiansson et al., 2012 | 21 | 30 | -14 | Medial orbital gyrus | right | fMRI, conjunction analysis; 21 male and female undergraduates; anger-related autobiographical memory |
| | 24 | 41 | -8 | Anterior orbital gyrus | right | |
| | 28 | 28 | -10 | Posterior orbital gyrus | right | |
| | 24 | 34 | -12 | Inferior frontal gyrus | right | |
| | 44 | 23 | 0 | Inferior frontal gyrus | right | |
| | 52 | 18 | 7 | Inferior frontal gyrus | right | |
| | 42 | 19 | 1 | Insula | right | |
| | 32 | 23 | -8 | Insula | right | |
| | 28 | 1 | -18 | Amygdala | right | |
| | 26 | -3 | -12 | Putamen | right | |
| | 15 | 22 | -6 | Caudate head | right | |
| | 46 | 9 | 4 | Precentral gyrus | right | |
| | 5 | -15 | 7 | Thalamus medial dorsal nucleus | right | |
| | 16 | -16 | 9 | Thalamus ventral lateral nucleus | right | |
| | 15 | -18 | 9 | Thalamus lateral posterior nucleus | right | |
| | 9 | -78 | -4 | Lingual gyrus | right | |
| | 25 | -2 | -10 | Lateral globus pallidus | right | |
| Schaefer et al., 2003 | -19 | -4 | -12 | Ventral pallidum | left | PET; 19 right-handed males; emotional mental imagery; reported results are unique to anger |
| de Greck et al., 2012 | -44 | -3 | 24 | Inferior frontal gyrus | left | fMRI; 32 Chinese and German, male and female students; intentional empathy towards angry familiar faces; reported results are transcultural constants |
| | -39 | -24 | 18 | Inferior frontal gyrus | left | |
| | 27 | 5 | 59 | Middle frontal gyrus | right | |
| | -7 | -7 | 57 | Supplementary motor area | left | |
| | 9 | -9 | 49 | Supplementary motor area | right | |
| | -30 | -25 | -6 | Anterior insula | left | |
| | -19 | -10 | -12 | Putamen | left | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | n/a | n/a | n/a | Occipital cortex | | |
| Pawliczek et al., 2013 | -8 | 10 | 26 | Dorsal anterior cingulate cortex | left | fMRI; male students; results reported are differential activation between high ($n$ = 21) and low ($n$ = 18) |
| | 0 | -68 | -24 | Cerebellum | | |
| | 4 | -6 | 0 | Thalamus | right | |
| | -22 | -6 | -12 | Amygdala | left | |
| | -34 | -44 | 28 | Inferior parietal | left | |
| | -24 | -18 | -2 | Lateral globus pallidus | left | |
| | 10 | -6 | -18 | Parahippocampal gyrus | right | |
| | 34 | 36 | 10 | Ventrolateral prefrontal cortex | right | |
| | -26 | -12 | 22 | Claustrum | left | |
| | -12 | -10 | 32 | Cingulate gyrus | left | |
| Kassam et al., 2013 | 18 | 3 | 22 | Caudate nucleus | right | fMRI; 10 male and female adult method actors; self-imagery of various emotions; activation patterns related to varied emotions grouped in factors; results reported are for Factor (5) with anger facet |
| | 20 | -27 | 67 | Precentral gyrus | right | |
| | -5 | 46 | 2 | Anterior cingulate | left | |
| Reuter et al., 2009 | -4 | -13 | -6 | Midbrain | left | VBM; 47 male and female adults; self-reported trait anger; results reported for positive and negative GM volume correlations |
| | 9 | -2 | -11 | Caudate | right | |
| | -25 | 0 | -25 | Amygdala parahippocampal gyrus (negative) | left | |
| | -19 | 0 | 61 | Superior frontal gyrus (negative) | left | |
| | -10 | -50 | -39 | Precuneus (negative) | left | |
| | -30 | 6 | -36 | Temporal lobe (negative) | left | |
| Denson et al., 2009 | 8 | 23 | 37 | Dorsal anterior cingulate | right | fMRI; 28 male and female right-handed undergraduates; interpersonal provocation within scanner; results reported for increased activation |
| | -8 | 22 | 36 | Dorsal anterior cingulate | left | |
| | 6 | 34 | 16 | Rostral anterior cingulate | right | |
| | 5 | 34 | -9 | Rostral anterior cingulate | right | |
| | -3 | 38 | -9 | Rostral anterior cingulate | left | |
| | 39 | 0 | 4 | Insula | right | |
| | -39 | 6 | 14 | Insula | left | |
| | 5 | -54 | 20 | Posterior cingulate | right | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | -8 | -46 | 23 | Posterior cingulate | left | |
| | -3 | -22 | 29 | Posterior cingulate | left | |
| | 7 | 51 | 15 | Medial frontal gyrus | right | |
| | 6 | 48 | 22 | Medial frontal gyrus | right | |
| | -5 | 37 | -12 | Medial frontal gyrus | left | |
| | 34 | 49 | 6 | Lateral middle frontal gyrus | right | |
| | -32 | 50 | 9 | Lateral middle frontal gyrus | left | |
| | 31 | -30 | -9 | Hippocampus | right | |
| | -32 | -30 | -9 | Hippocampus | left | |
| | -14 | -9 | 0 | Thalamus | left | |
| Kimbrell et al., 1999 | 6 | -37 | 10 | Thalamus | right | PET; 18 male and female adults; self induced anger paired with images of corresponding faces; results reported positively and negatively correlated |
| | 44 | 21 | -23 | Superior temporal | right | |
| | -48 | 13 | -22 | Superior temporal | left | |
| | -20 | 34 | -8 | Medial frontal gyrus | left | |
| | 48 | -16 | 8 | Superior temporal gyrus (negative) | right | |
| | 49 | 32 | 23 | Inferior parietal (negative) | right | |
| | 39 | 11 | 37 | Middle frontal gyrus (negative) | right | |
| Dougherty et al., 1999 | -37 | 29 | -21 | Lateral orbitofrontal cortex | left | PET; 8 male adults; emotional response to hypothetical vignettes |
| | -46 | 22 | -9 | Lateral orbitofrontal cortex | left | |
| | 19 | 35 | 21 | Rostral anterior cingulate | right | |
| | -51 | -4 | -9 | Anterior temporal pole | left | |
| | 48 | 14 | -28 | Anterior temporal pole | right | |
| | -36 | -15 | 48 | Precentral gyrus | left | |
| | -28 | 46 | 17 | Medial frontal gyrus | left | |
| | 0 | 64 | -2 | Medial frontal gyrus | left | |
| | -1 | -55 | 29 | Cerebellum | left | |
| Damasio et al., 2000 | -3 | -28 | -19 | Pons | left | PET; 41 male and female adults; self induced emotion; results reported positive and negative correlations with anger and a priori regions |
| | 14 | -21 | -1 | Midbrain | right | |
| | -11 | -24 | -10 | Midbrain | left | |
| | -6 | -8 | -4 | Hypothalamus | left | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 38 | 14 | -2 | Insula | right | |
| | -38 | 17 | -9 | Insula | left | |
| | -43 | -2 | 10 | Insula | left | |
| | n/a | n/a | n/a | Anterior cingulate | right | |
| | 12 | 47 | 14 | Anterior cingulate (negative) | right | |
| | -5 | 38 | 10 | Anterior cingulate | left | |
| | -13 | -3 | 36 | Anterior cingulate | left | |
| | -9 | -36 | 33 | Anterior cingulate | left | |
| | 8 | -32 | 47 | Posterior cingulate (negative) | right | |
| | 6 | -36 | 41 | Posterior cingulate (negative) | right | |
| | -9 | -36 | 33 | Posterior cingulate | left | |
| | -3 | -50 | 43 | Posterior cingulate (negative) | left | |
| | 50 | -16 | 19 | SII (negative) | right | |
| | -39 | -23 | 17 | SII (negative) | left | |
| | 13 | 44 | -18 | Orbitofrontal (negative) | right | |
| Alia-Klein et al., 2009 | -24 | 0 | -22 | Amygdala (reactivity) | left | fMRI; 27 nonsmoking males; vocalized provocation (i.e. "No") |
| | -16 | -5 | 4 | Anterior thalamus (control; negative) | left | activation predicting anger reactivity and anger control; results report positive and negative correlations |
| Satpute et al., 2013 | no | coordinates | given | Caudal ventrolateral PAG (negative) | left | fMRI; 11 right-handed male and female adults; self-reported affective response to images; results reported distinctive to angry affect and negatively correlated |
| Pardini et al., 2014 | no | coordinates | given | Amygdala (negative) | bilateral | MRI; 56 male adults; self-reported aggression, violent crime, and psychopathic traits; results report negative correlation |

| | | | | | | |
|---|---|---|---|---|---|---|
| Grafman et al., 1996 | no | coordinates | given | Frontal ventromedial | bilateral | Computerized tomography; Vietnam Head Injury Study; 279 male veterans; self-reported aggression and violence |

Note: “n/a” denotes that the published coordinates appear to be incorrect (i.e. they were not located within the brain); we assumed the region of interests were reported correctly, and so they were kept in the table.

While our present work focuses on the neuroanatomical correlates of anger in healthy individuals, it is worth noting that the brain regions detailed above have also been linked to anger in psychiatric populations. For example, reduced GM in ventrolateral prefrontal cortex and orbitofrontal cortex has been observed in individuals with antisocial personality disorder (Raine et al., 2000; Raine et al., 2011). Moreover, reduced neural activation in these brain areas has been found in individuals with high-trait anger and concurrent major depressive disorder (Dougherty et al., 2004). Overlaps between the healthy and clinical literatures are also evident in subcortical regions. A review of schizophrenics with aggression indicated that this group was characterised by reductions in GM in the amygdala and structural abnormalities of the orbitofrontal cortex, as compared to schizophrenics without aggression (Naudts & Hodgins, 2006). And in a sample of post-stroke patients, the inability to regulate anger expression was most strongly related to lesions to the frontal-lenticulocapsular-pontine base areas (Kim et al., 2002); notably, these areas are adjacent to the thalamus and PAG.

In short, using the coordinates provided by the neuroimaging investigations described above, evidence for a relationship between affective anger and regions of the brain can be seen most consistently in the PAG (Damasio et al., 2000; Satpute et al., 2013), hypothalamus (Denson et al., 2009; Fabiansson et al., 2012), amygdala (Alia-Klein et al., 2009; Pardini et al., 2014; Pawliczek et al., 2013), and both medial and lateral prefrontal regions (Denson et al., 2009; Dougherty et al., 1999; Grafman et al., 1996; Pawliczek et al., 2013). Additional coordinates being noted include the insula cortex (Damasio et al., 2000; Denson et al., 2009; Fabiansson et al., 2012), anterior cingulate (Damasio et al., 2000; Kassam et al., 2013), and middle and inferior frontal gyrus (de Greck et al., 2012; Denson et al., 2009; Fabiansson et al., 2012; Kimbrell et al., 1999).

### The current study

As noted above, a range of neuroscience methods have indicated that several brain regions play an important role in the expression of anger (and aggression): amygdala, portions of medial frontal cortex, PAG, insula, anterior cingulate, middle and inferior frontal gyrus, and hypothalamus. To date, however, little work has addressed GM links to anger in a general population (but see Reuter et al., 2009). With these observations in mind we seek to examine the neuroanatomical links to anger using voxel-based morphometry (Ashburner & Friston, 2000). Building on the research summarised above we have several directional hypotheses. These hypotheses are based upon several lines of evidence indicating that activation-dependent regional GM structural changes occur relative to frequency of use (Draganski et al., 2004; Draganski et al., 2006; Driemeyer et al., 2008). Therefore, we reason that relative volumetric variation will be observed in regions associated with the experience of anger. Specifically, we hypothesise that trait anger will be positively correlated with GM in the PAG and negatively correlated with GM in the amygdala, medial prefrontal cortex, insula, anterior cingulate, and ventrolateral prefrontal cortex. To the best of our knowledge, no prior neuroimaging investigations have fractionated anger in a way similar to that which is being done here. Therefore, we are taking an exploratory approach towards GM correlates of expressions of anger – as defined by the State-Trait Anger Expression Inventory (STAXI; Spielberger, 1996) – without any specific hypotheses.

## Methods

### Participants

These analyses were run on a data collected from a cohort of participants who were contacted following prior (and unrelated) neuroimaging studies in order to capitalise on the fact that high resolution neuroanatomical data had already been acquired for these individuals. Accordingly, a survey was posted to all applicable individuals. From this secondary recruitment drive 108 participants completed our survey. Only participants who satisfied the following criteria were included in the final analyses: having a structural scan no more than 36 months old, no prior neurological or psychiatric diagnoses or history of prescribed medication for psychiatric or neurological disorders, no prior brain injury, right-handed, and aged 18-65. With these criteria applied, the final sample consisted of 74 individuals: 31 males (mean age = 23.55; SD = 5.25) and 43 females (mean age = 22.21; SD = 2.42). By race, 81.1% (*n* = 60) of the population identified as White, 10.8% (*n* = 8) as Chinese, 2.7% (*n* = 2) as Other Asian, 1.4% (*n* = 1) as Indian, 1.4% (*n* = 1) as Hispanic, and 2.7% (*n* = 2) as Mixed.

**Measures**

**Anger and anger expression.** Anger was measured by the self-administration of the State-Trait Anger Expression Inventory (STAXI; Spielberger, 1996), and reported scores for the subscales Trait Anger, Anger Expression–In (AX/IN), Anger Expression-Out (AX/Out), and Anger Control (AX/C). The STAXI scales consisted of four to fifteen items which participants rated on a four-point Likert scale. Example items include: “I have a fiery temper” (trait anger), “I boil inside, but don’t show it” (AX/IN), “I strike out at whatever infuriates me” (AX/Out), and “I keep my cool” (AX/C). Scale scores were constructed by the summing across items for which there was no or only one missing value. Because we were interested in stable dispositions or tendencies to experience anger the State Anger subscale was not included in our analysis, and therefore not reported on further.

Cronbach's alpha for each of the STAXI facets were all good to excellent levels: trait anger α = .84, AX/IN α = .69, AX/Out α = .74, and AX/C α = .70.

**MRI data acquisition.** MR images were acquired with a GE 3-Tesla HDX Excite MRI scanner at the York Neuroimaging Centre. High-resolution anatomical images were acquired using a T1-weighted 3D fast spoiled gradient echo (FSPGR) sequence (TR = 7.8 ms; TE = 3 ms; FOV = 290 × 290 × 176 mm; voxel size = 1 × 1 × 1 mm).

**Voxel-based morphometry.** Firstly, the structural images were segmented for gray matter (GM), white matter, and cerebral spinal fluid using the segmentation tools in SPM8 (http://www.fil.ion.ucl.ac.uk/spm). Secondly, inter-subject registration of the GM images were performed using Diffeomorphic Anatomical Registration Through Exponentiated Lie Algebra (DARTEL) in SPM8. Image intensity for each voxel was modulated by the Jacobian determinants of the deformation fields to ensure that local GM volume was conserved after spatial transformation. The registered images was smoothed with a Gaussian kernel (FWHM = 8 mm) and transformed to MNI stereotactic space by means of affine and non-linear spatial normalisation implemented in SPM8 for multiple regression analysis. Covariates in the analysis included gender, age, and whole-brain GM volume.

We built a mask that included the regions of interest (ROIs) identified in previous research (see above and Table 4.1) in order to minimise the multiple-testing burden. ROIs were identified by locating coordinates reported by previous research (see Table 4.1) within the anatomical masks defined in the AAL atlas extension (Tzourio-Mazoyer et al., 2002) for MarsBaR (Brett et al., 2002). We included anatomical masks that captured coordinates in at least two previous studies of anger. Due to the robust findings involving the PAG in the experience of anger (Damasio et al., 2000; Panksepp, 1998; Satpute et al., 2013), and because this region does not have a predefined mask in MarsBaR, we manually created a mask for this region. These individual masks were combined into a single mask

for use in our analyses. This single mask created for analysis included a 10mm sphere centred around the PAG (MNI coordinates, x = -4.0, y = -29.0, z = -12.0) and the following bilateral regions as defined in the AAL atlas extension (Tzourio-Mazoyer et al., 2002) for MarsBaR (Brett et al., 2002): amygdala, frontal inferior orbital, anterior cingulate, median cingulate, middle frontal gyrus, insula, frontal inferior gyrus – opercular part, frontal medial orbital, precentral gyrus, and thalamus. We used the FWE peak voxel $p < .05$ as our nominal threshold correcting for multiple comparisons.

In a final analysis we performed an exploratory whole-brain analysis using the non-stationary toolbox (Hayasaka et al., 2004) while correcting (FWE peak voxel $p < .05$) for multiple comparisons and controlling for total GM volume.

For the analyses described above, following the advice of Woo, Krishnan and Wager (2014), we chose to set the initial uncorrected threshold of $p < .001$ at each voxel after recent evidence indicates that liberal primary thresholds (e.g. $p < .01$, $p < .005$) have been shown to produce unacceptably high numbers of false positives (Woo, Krishnan, & Wager, 2014).

## Results

Data from each of the anger scales was normally distributed and descriptive statistics for each of the variables are presented in Table 4.2.

Table 4.2. *Descriptive statistics for the study variables.*

| | Mean | *SD* |
|---|---|---|
| Trait Anger | 1.93 | .44 |
| Anger-In | 2.52 | .49 |
| Anger-Out | 1.58 | .38 |
| Anger-Control | 2.50 | .54 |
| Age | 22.77 | 3.89 |

Note: $n = 74$; *SD* = standard deviation.

While correcting for multiple comparisons is a crucial step towards avoiding the high risk of a Type I error due to the large number of statistical tests, failing to observe and report uncorrected values may overlook important, yet small, effects. Therefore, we also report significant results at the uncorrected level, in line with prior investigations (e.g., Lieberman & Cunningham, 2009; Poldrack et al., 2008) that emphasize this as an effort to not overlook potentially real effects in the form of Type II errors and to present findings for future meta-analyses.

Using the FWE peak voxel $p < .05$ as our nominal threshold to correct for multiple comparisons we failed to find any GM correlates of trait anger at a statistically significant level within the defined ROI. At an uncorrected level and within the ROI, trait anger was positively correlated with the GM volume in the right ventrolateral prefrontal cortex (vlPFC; *P* (uncorr) < .001, $r = .43$, $t(69) = 3.92$). For reference this positive correlation is presented in Table 4.3 and Figure 4.1. Within the ROI, trait anger was not negatively correlated with GM at uncorrected levels ($p > .05$). Whole brain analysis, correcting for non-stationarity, revealed no significant positive or negative correlations between GM and trait anger.

Table 4.3. *Positive association between GM and trait anger*.

| Area | H | MNI coordinates of peak voxel | | | Correlation (Pearson's *r*) | *t*(69) | Cluster size (voxels) | *P*(uncorr) |
|---|---|---|---|---|---|---|---|---|
| | | *X* | *Y* | *Z* | | | | |
| vlPFC | R | 39 | 47 | 4 | 0.43 | 3.92 | 133 | < 0.001 |

Note: vlPFC = ventrolateral prefrontal cortex; H = hemisphere; R = right; *P*(uncorr) denotes the *P*-values uncorrected for multiple comparisons at the cluster level across the region of interest (see 'Methods' section for details).

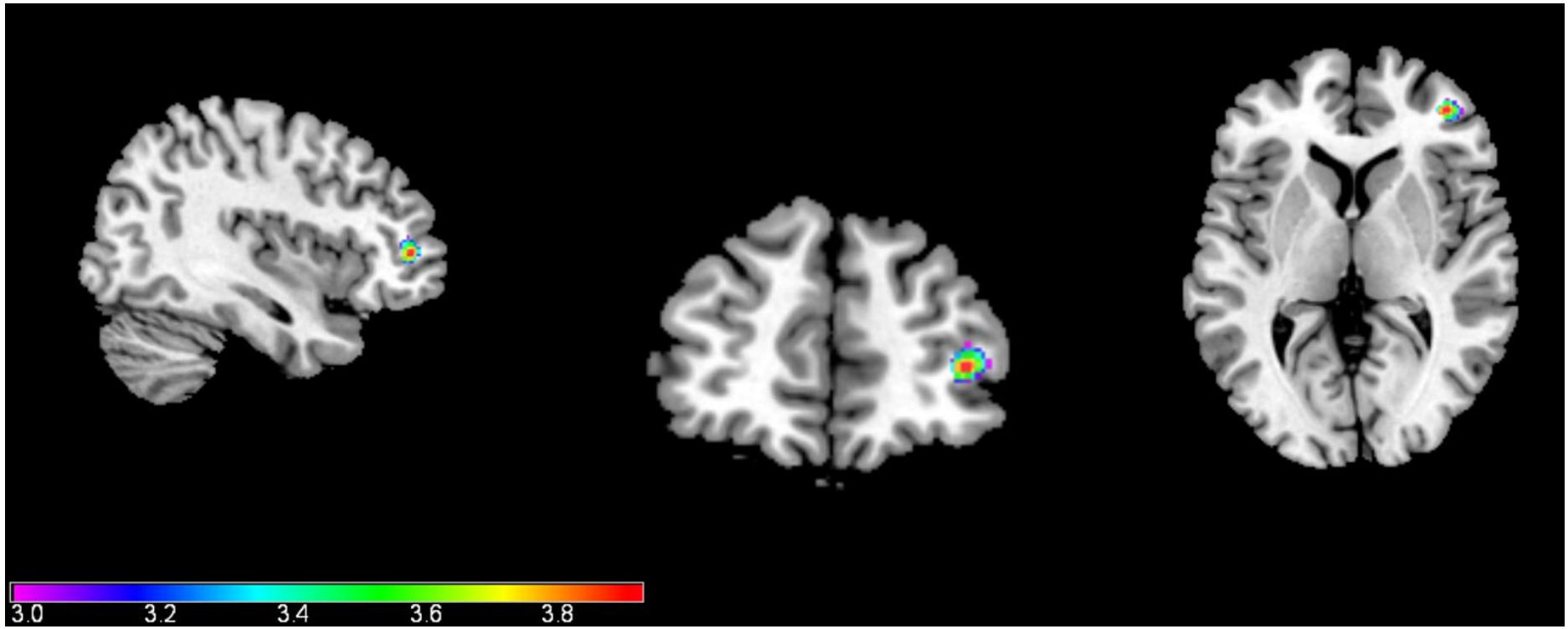


*Figure 4.1.* Region where GM volume was associated with trait anger is overlaid on a T1-weighted standard MNI template; t-values are overlaid for the right ventrolateral prefrontal cortex, showing significant positive correlation (uncorrected) in the VBM analysis (see main text). The colour bar illustrates the corresponding t-values.

Using the FWE peak voxel $p < .05$ as our nominal threshold to correct for multiple comparisons we failed to find any GM correlates of AX/IN at a statistically significant level within the ROI. At an uncorrected level and within the ROI, AX/IN was positively correlated with GM volume in the left insula (*P* (uncorr) < .001, *r* = .40, *t*(69) = 3.43). For reference this positive correlation is presented in Table 4.4 and Figure 4.2. Negative correlations, at the uncorrected level and within the ROI, were found in the left precentral gyrus (*P* (uncorr) < .001, *r* = .40, *t*(69) = 3.62) and right precentral gyrus (*P* (uncorr) < .001, *r* = .40, *t*(69) = 3.58). For reference these negative correlations are presented in Table 4.5 and Figure 4.3. Whole brain analysis, correcting for non-stationarity, revealed no significant positive or negative correlations between GM and AX/IN.

Table 4.4. *Positive associations between GM and AX/IN.*

| Area | H | MNI coordinates of peak voxel | | | Correlation (Pearson's *r*) | *t*(69) | Cluster size (voxels) | *P*(uncorr) |
|---|---|---|---|---|---|---|---|---|
| | | *X* | *Y* | *Z* | | | | |
| Insula | L | -34 | 12 | -17 | 0.40 | 3.60 | 21 | < 0.001 |
| | | -28 | 11 | -14 | 0.35 | 3.13 | | < 0.005 |

Note: H = hemisphere; L = left; *P*(uncorr) denotes the *P*-values uncorrected for multiple comparisons at the cluster level across the region of interest (see 'Methods' section for details).

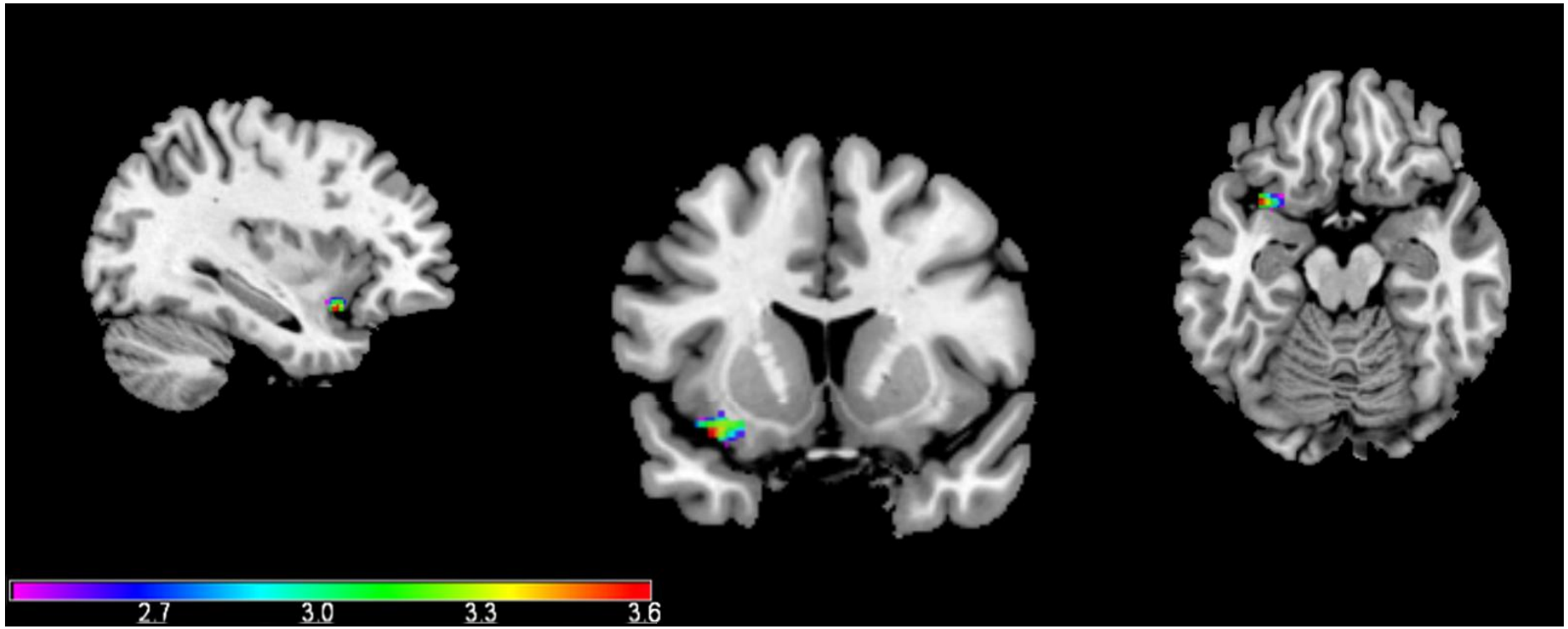


*Figure 4.2.* Region where GM volume was associated with AX/IN are overlaid on a T1-weighted standard MNI template; t-values are overlaid for the left insula, showing significant positive correlation (uncorrected) in the VBM analysis (see main text). The colour bar illustrates the corresponding t-values.

Table 4.5. *Negative associations between GM and AX/IN.*

| Area | H | MNI coordinates of peak voxel | | | Correlation (Pearson's *r*) | *t*(69) | Cluster size (voxels) | *P*(uncorr) |
|---|---|---|---|---|---|---|---|---|
| | | *X* | *Y* | *Z* | | | | |
| Precentral gyrus | L | -22 | -13 | 64 | -0.40 | 3.62 | 33 | < 0.001 |
| Precentral gyrus | R | 52 | 9 | 4 | -0.40 | 3.58 | 69 | < 0.001 |
| | | 51 | 11 | -2 | -0.39 | 3.55 | | < 0.001 |

Note: H = hemisphere; L = left; R = right; *P*(uncorr) denotes the *P*-values uncorrected for multiple comparisons at the cluster level across the region of interest (see 'Methods' section for details).

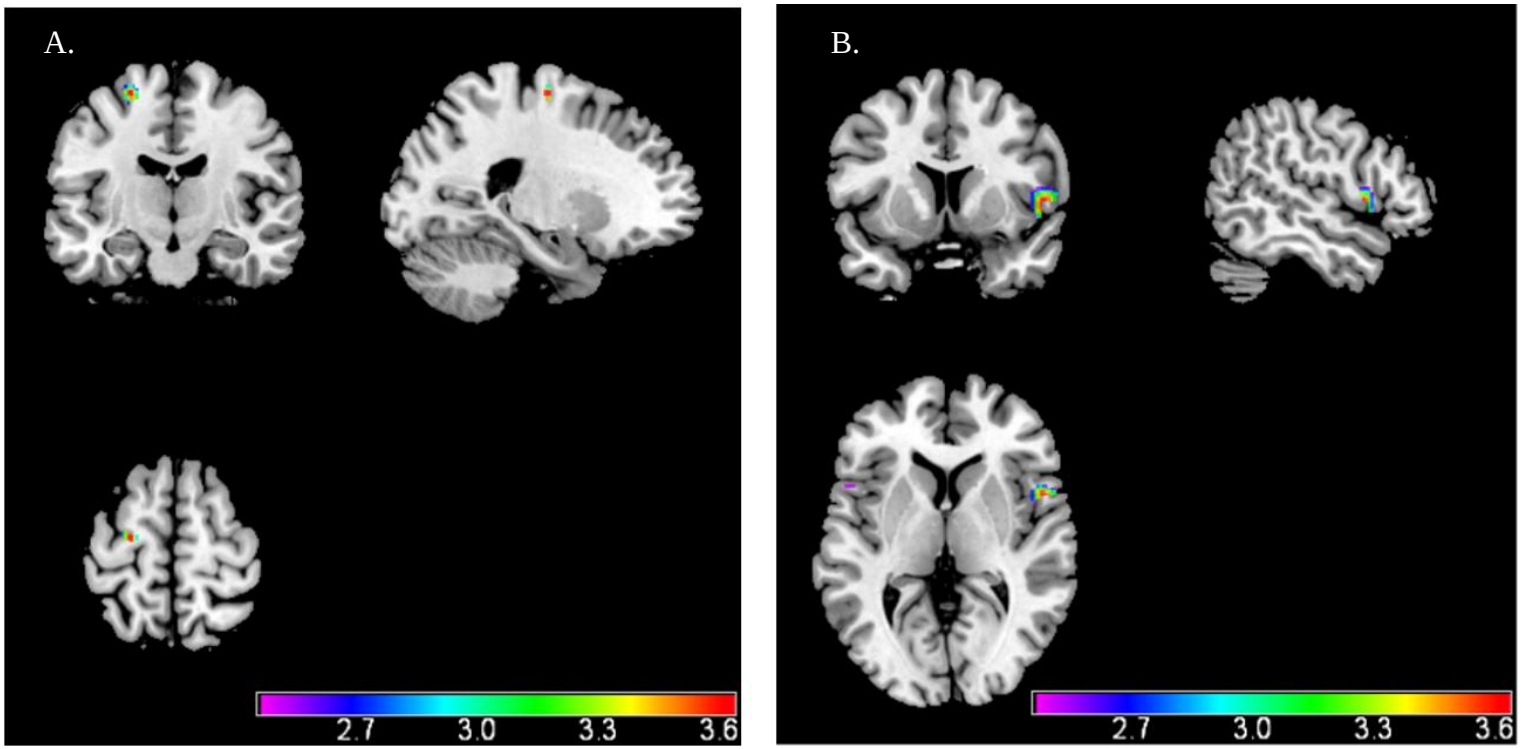


*Figure 4.3.* Regions where GM volume was associated with AX/IN is overlaid on a T1-weighted standard MNI template; t-values are overlaid for the regions that showed a significant negative correlation (uncorrected) in the VBM analysis (see main text). The colour bars illustrate the corresponding t-values. Image A depicts correlations occurring at the left precentral gyrus (MNI coordinates: -22, -13, 64). Image B depicts correlations occurring at the right precentral gyrus (MNI coordinates: 52, 9, 4).

Using the FWE peak voxel $p < .05$ as our nominal threshold to correct for multiple comparisons we failed to find any GM correlates of AX/Out at a statistically significant level within the ROI. At an uncorrected level and within the ROI, AX/Out was positively correlated with the GM volumes in the left precentral gyrus (*P*(uncorr) < .001, *r* = .39, *t*(69) = 3.51) and the right dorsolateral prefrontal cortex (dlPFC; *P*(uncorr) < .005, *r* = .38, *t*(69) = 3.37). For reference these positive correlations are presented in Table 4.6 and Figure 4.4. Within the ROI, AX/Out was not negatively correlated with GM at uncorrected levels ($p > .05$). Whole brain analysis, correcting for non-stationarity, revealed no significant positive or negative correlations between GM and AX/Out.

Table 4.6. *Positive associations between GM and AX/Out.*

| Area | H | MNI coordinates of peak voxel | | | Correlation (Pearson's *r*) | *t*(69) | Cluster size (voxels) | *P*(uncorr) |
|---|---|---|---|---|---|---|---|---|
| | | *X* | *Y* | *Z* | | | | |
| Precentral gyrus | L | -44 | -4 | 46 | 0.39 | 3.51 | 9 | < 0.001 |
| dlPFC | R | 31 | 38 | 24 | 0.38 | 3.37 | 5 | < 0.005 |

Note: dlPFC = dorsolateral prefrontal cortex; H = hemisphere; L = left; R = right; *P*(uncorr) denotes the *P*-values uncorrected for multiple comparisons at the cluster level across the region of interest (see 'Methods' section for details).

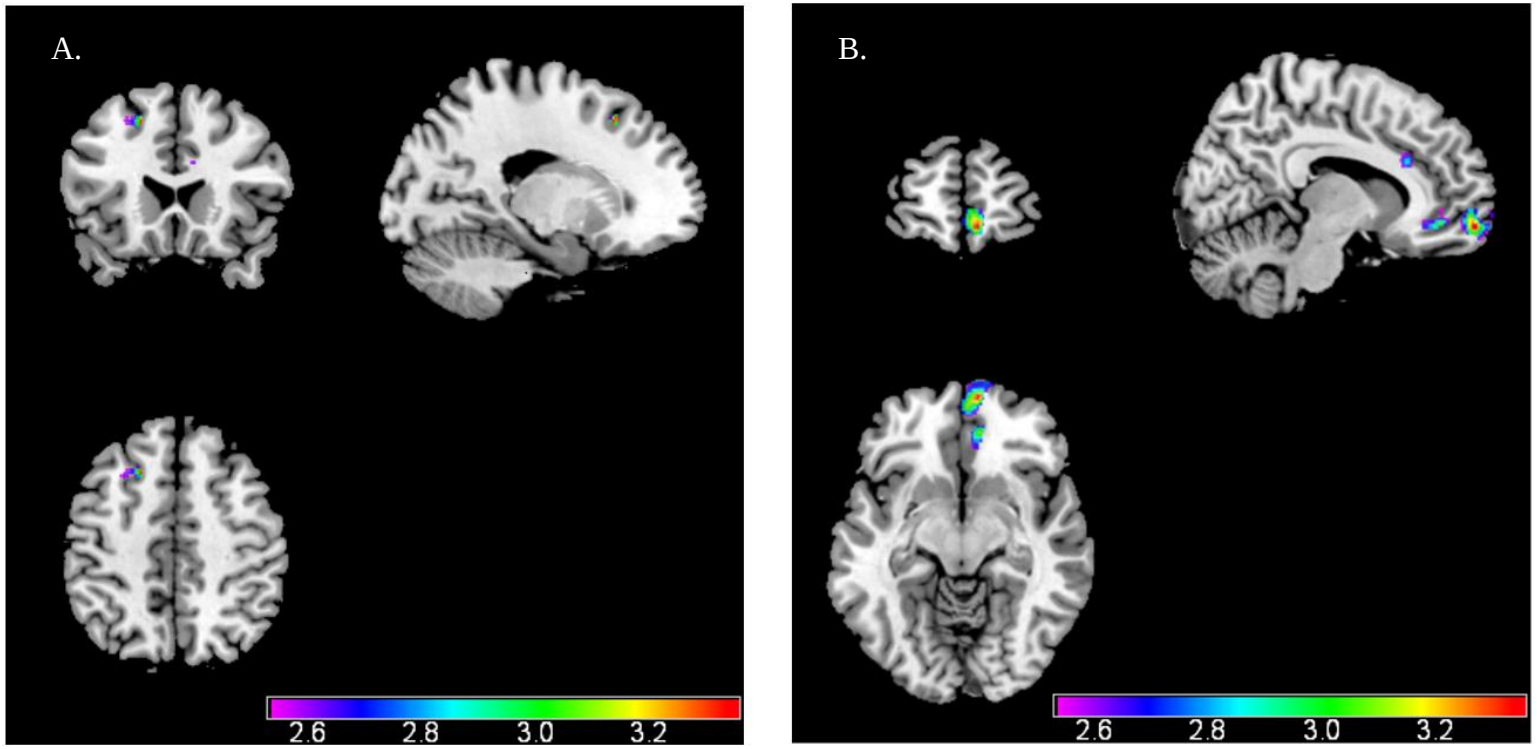


*Figure 4.4.* Regions where GM volume was associated with AX/Out is overlaid on a T1-weighted standard MNI template; t-values are overlaid for regions that showed significant positive correlations (uncorrected) in the VBM analysis (see main text). The colour bar illustrates the corresponding t-values. Image A depicts correlations occurring at the left precentral gyrus (MNI coordinates: -44, -4, 46). Image B depicts correlations occurring at the right dorsolateral prefrontal cortex (MNI coordinates: 31, 38, 24).

Using the FWE peak voxel $p < .05$ as our nominal threshold to correct for multiple comparisons we failed to find any GM correlates of AX/C at a statistically significant level within the ROI. At an uncorrected level and within the ROI, AX/C was positively correlated with the GM volumes in the left SFG ($P$(uncorr) < .005, $r$ = .37, $t$(69) = 3.35) and the right orbitofrontal cortex (OFC; $P$(uncorr) < .005, $r$ = .37, $t$(69) = 3.34). For reference these positive correlations are presented in Table 4.7 and Figure 4.5. A negative correlation, within the ROI and at an uncorrected level, was found in the left mPFG ($P$(uncorr) < .001, $r$ = .39, $t$(69) = 3.52). For reference this negative correlation is presented in Table 4.8 and Figure 4.6. Whole brain analysis, correcting for non-stationarity, revealed no significant positive or negative correlations between GM and AX/C.

Table 4.7. *Positive associations between GM and AX/C.*

| Area | H | MNI coordinates of peak voxel | | | Correlation (Pearson's *r*) | *t*(69) | Cluster size (voxels) | *P*(uncorr) |
|---|---|---|---|---|---|---|---|---|
| | | *X* | *Y* | *Z* | | | | |
| SFG | L | -18 | 21 | 48 | 0.37 | 3.35 | 4 | < 0.005 |
| OFC | R | 9 | 60 | -9 | 0.37 | 3.34 | 10 | < 0.005 |

Note: SFG = superior frontal gyrus; OFC = orbitofrontal gyrus; H = hemisphere; L = left; R = right; *P*(uncorr) denotes the *P*-values uncorrected for multiple comparisons at the cluster level across the region of interest (see 'Methods' section for details).

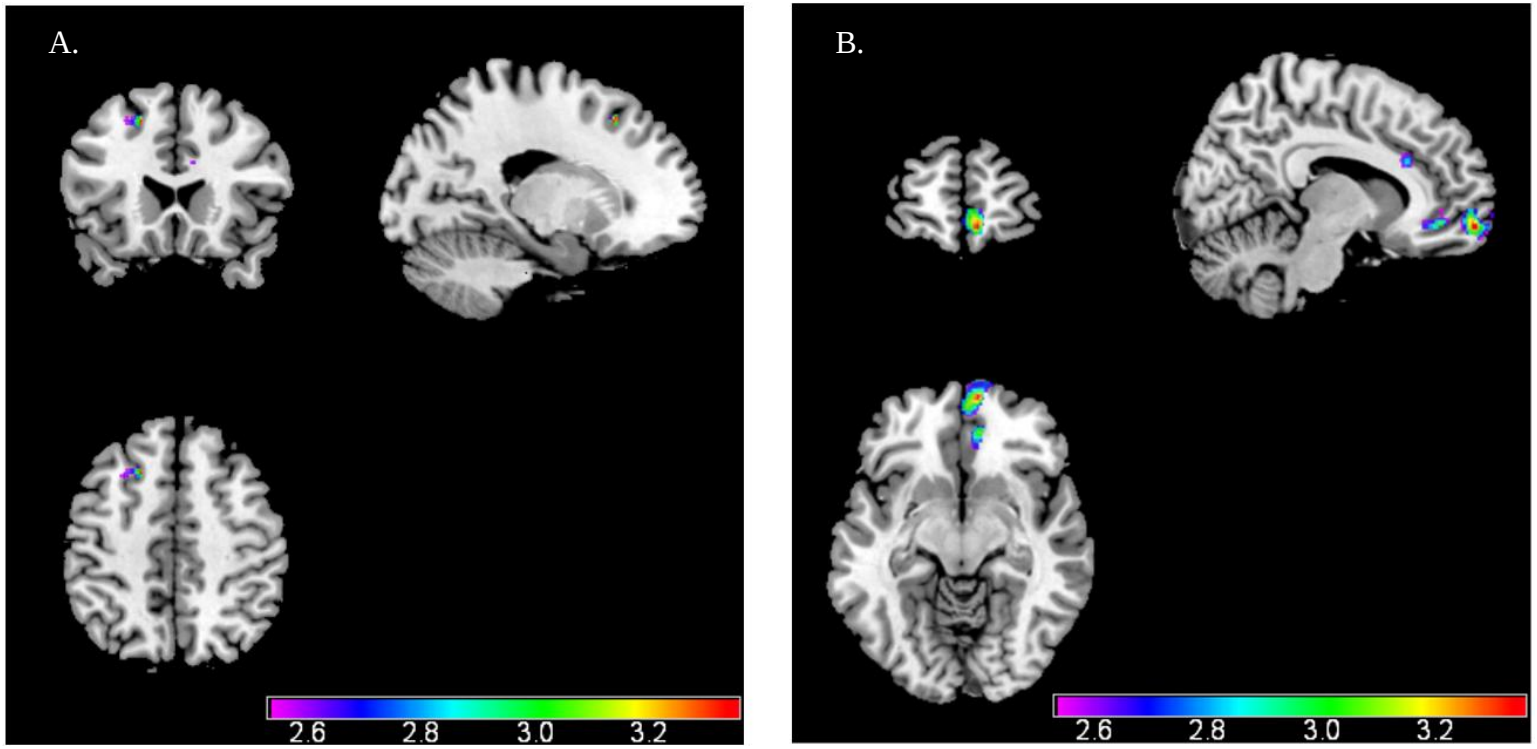


*Figure 4.5.* Regions where GM volume was associated with AX/C is overlaid on a T1-weighted standard MNI template; t-values are overlaid for regions that showed significant positive correlations (uncorrected) in the VBM analysis (see main text). The colour bar illustrates the corresponding t-values. Image A depicts correlations occurring at the left superior frontal gyrus (MNI coordinates: -18, 21, 48). Image B depicts correlations occurring at the right orbitofrontal cortex (MNI coordinates: 9, 60, -9).

Table 4.8. *Negative association between GM and AX/C.*

| Area | H | MNI coordinates of peak voxel | | | Correlation (Pearson's *r*) | *t*(69) | Cluster size (voxels) | *P*(uncorr) |
|---|---|---|---|---|---|---|---|---|
| | | *X* | *Y* | *Z* | | | | |
| mPFG | L | -42 | 14 | 31 | -0.39 | 3.52 | 19 | < 0.001 |

Note: mPFG = medial prefrontal gyrus; H = hemisphere; L = left; *P*(uncorr) denotes the *P*-values uncorrected for multiple comparisons at the cluster level across the region of interest (see 'Methods' section for details).

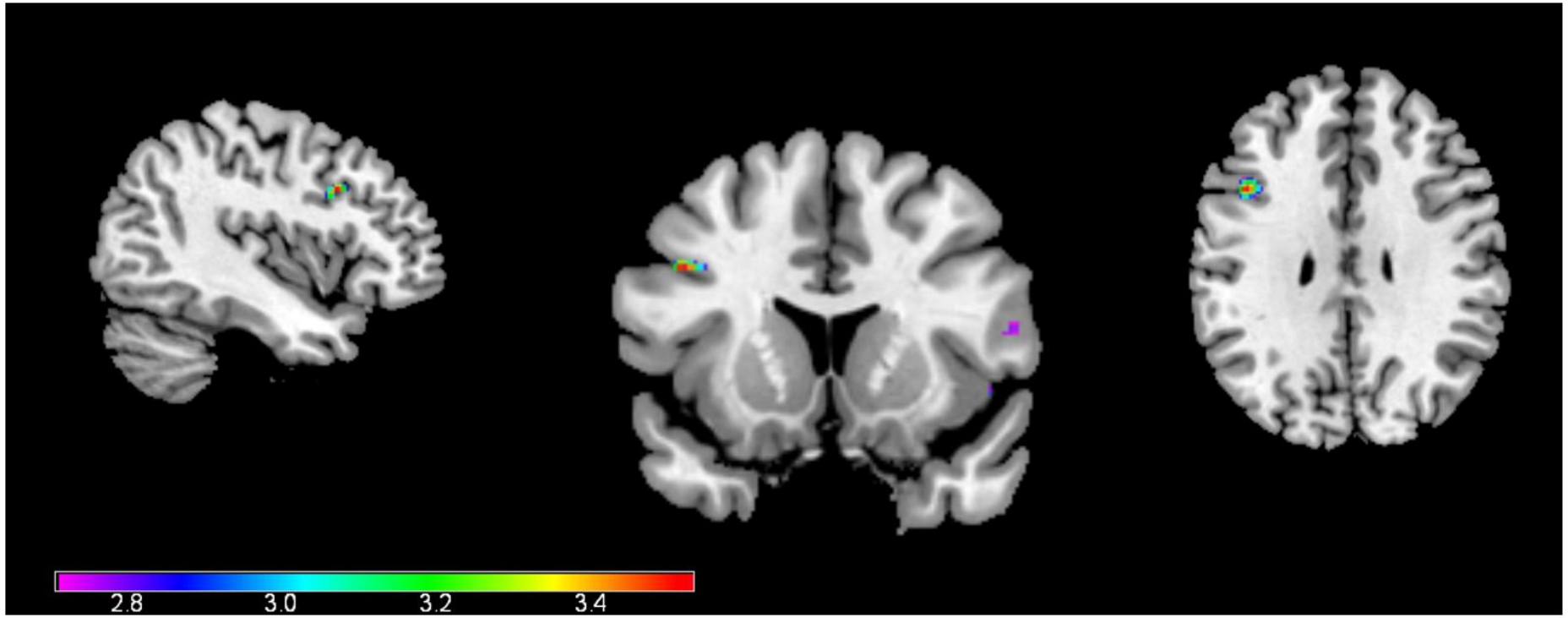


*Figure 4.6.* Region where GM volume was associated with AX/C is overlaid on a T1-weighted standard MNI template; t-values are overlaid for the left medial prefrontal gyrus, showing a significant negative correlation (uncorrected) in the VBM analysis (see main text). The colour bar illustrates the corresponding t-values.

## Discussion

Here we conducted an analysis of regional GM volume in relation to scores on the scales Trait Anger, Anger Expression–In (AX/IN), Anger Expression-Out (AX/Out), and Anger Control (AX/C). After performing a comprehensive (to the best of our knowledge) literature review of the functional and neuroanatomical research related to anger in healthy cohorts, we identified several regions of interest that shaped our a priori predictions. Based upon previous findings we predicted that trait anger would be positively correlated with gray matter (GM) in the PAG and negatively correlated with GM in the amygdala, medial prefrontal cortex, insula, anterior cingulate, and vlPFC. Our analyses related to the other STAXI scales were of an exploratory nature. At the corrected thresholds described above (see Methods section) we failed to find any significant results related to our predictions or any of the STAXI scales.

We failed to find any statistically significant correlations between trait anger and reductions in GM within the ROI analysis, nor for variations in either direction of GM within the exploratory whole-brain analysis. These results were somewhat surprising considering the prior structural and functional investigations outlined in Table 4.1.

As stated above, we have reported significant results at the uncorrected level in an attempt to minimize the likelihood of a Type II error and for future reference in meta-analyses (Lieberman & Cunningham, 2009; Poldrack et al., 2008). In line with this, all results presented in this section will describe exploratory analyses that did not correct for multiple comparisons. To this end, we did find evidence for a positive correlation ($p < .001$), albeit in an exploratory step that did not correct for multiple comparisons, between GM volume in the right vlPFC and trait anger. This result was in the opposite direction to our prediction which was built upon previous investigations. Prior research reports a

negative relationship between GM volume in and around the vlPFC and anger in cohorts of individuals with antisocial personality disorder (Raine et al., 2000; Raine et al., 2011) and individuals with traumatic brain injury lesions (Grafman et al., 1996). Additionally, because the vlPFC and surrounding area has been associated with planning and executing long-term goals in spite of immediate environmental demands (Koechlin et al., 1999; Koechlin & Hyafil, 2007), we reasoned that increased availability of computational resources (i.e. GM) in this location would relate to decreased trait anger – individuals would have increased ability to inhibit angry responses, more effectively regulating their emotional state. However, since the specific relationship between a brain region's structure and function is still largely unknown, we must conclude that the relationship seen here isn't as straight forward as initially thought. Indeed, increased GM in the vlPFC and surrounding areas has been found by investigations into other instances of abnormal impulse control such as obesity (Horstmann et al., 2011) and pathological gambling (Koehler et al., 2013).

A positive relationship ($p < .005$) was seen between GM and AX/IN in the left insula, while negative correlations ($p < .001$) were seen bilaterally in the precentral gyrus. Previous investigations have reported anger-related activation in the insula (Damasio et al., 2000; Denson et al., 2009; Fabiansson et al., 2012), with additional evidence suggesting that the insula is partly responsible for homeostatic regulation (Damasio et al., 2000) as well as modulating decision making in affective states (Singer et al., 2009). Moreover, increased volume in the insula is related to effectively using expressive suppression – an emotion regulation strategy that inhibits outward expressions of generated affective states – techniques (Giuliani et al., 2011). Therefore, it's no surprise that we see a relationship between GM in the left insula and the STAXI scale that describes a tendency to direct anger inwards. The left and right precentral gyri have been implicated in anger-related

activation across multiple studies (Dougherty et al., 1999; Fabiansson et al., 2012; Kassam et al., 2013), as well as response inhibition (Liddle, Kiehl, & Smith, 2001).

A positive relationship was seen between AX/Out and GM volumes in the left precentral gyrus ($p < .001$) and right dorsolateral prefrontal cortex (dlPFC; ($p < .005$), while there were no statistically significant negative correlations. As outlined in the preceding text, prior studies have found a relationship between anger-related activation and the precentral gyrus. However, in light of findings associating this region with increased response inhibition (Liddle et al., 2001), and since higher levels of AX/Out suggest a decreased ability to inhibit outwardly directed anger-related impulses, we are limited in our ability to explain or justify the direction of the relationship seen here. To that end, we can only put forth that future investigations consider the precentral gyri as a potential ROIs related to anger. Likewise, the positive correlation between AX/Out and GM in the dlPFC is worth further investigation, as we are unable to speculate as to why such a relationship exists. More specifically, while reductions in the dlPFC's GM volume have been associated with a variety of issues stemming from reduced inhibitory control – e.g. depression (Grieve et al., 2013), manic episodes (Ekman et al., 2010), startle response (Day-Wilson et al., 2006) – we were unable to locate any evidence to suggest why an increase in this volume might relate to an increase in outwardly expressed anger.

Several relationships were seen between GM volume and AX/C. Positive correlations were present ($p < .005$) between AX/C and GM volume in the left SFG – a finding that is in the opposite direction as Reuter and colleagues' (2009) reported findings – and right orbitofrontal cortex (OFC). Given the SFG's role in inhibitory control (Li et al., 2006; Padmala & Pessoa, 2010) it is not entirely surprising that a relationship may exist between this region and the ability to successfully control experiences of affective anger. Specifically, the left SFG is implicated in working memory (du Boisgueheneuc et al.,

2006) which is positively correlated with emotional regulation (Engen & Kanske, 2013). Functional activation in the right OFC has been associated with the appraisal of social-emotional stimuli (Bechara et al., 2000; Damasio et al., 2000), particularly positive (e.g. joy, humour) emotions (Britton et al., 2006). This suggests that perhaps an increase of GM in the OFC region relates to both increased ability to process emotional stimuli, and a preference for a positive, versus negative, affective state. A negative correlation ($p < .001$) was seen between GM and AX/C in the left medial prefrontal gyrus (mPFG). Anger-related activation in this region has been reported by a number of studies (de Greck et al., 2012; Denson et al., 2009; Dougherty et al., 1999) with a negative correlation reported by (Kimbrell et al., 1999), yet this region has also been shown to relate to inhibitory control (Garavan et al., 2006; van der Meer et al., 2011). Without an explanation as to why there is an apparent dissonance between findings related to the mPFG, we emphasize the need for future analyses related to this region.

A limitation of this study was the use of only a self-report measure, which is vulnerable to social-desirability effects, to capture anger and its expressions. Including behavioural measures of anger and anger expression may allow for a more accurate portrayal of participants' anger. Another limitation may have been the type of analysis conducted. Evidence from Winkler and colleagues (2010) indicates that while VBM remains a valid analytic technique, it overlooks the relationship between cortical GM volume and cortical thickness, depending solely on a region's surface area. Future work should consider including both cortical thickness and surface area in the analysis and – if logistically feasible – a behavioural component measuring anger and its expressions. A third limitation may have been the sample size used for this analysis. While every attempt was made to recruit as many participants as possible, a larger cohort would have enabled greater statistical power in all analyses – potentially revealing small effects.

In conclusion, evidence was found for a positive relationship between GM in the vlPFC and trait anger. However, this effect did not survive correction for multiple comparisons. No evidence was found for a negative relationship between trait anger and GM anywhere within our ROI, nor did an exploratory whole-brain analysis reveal a statistically significant effect. Future work should focus on replicating the methodology used here on a larger and representative sample.

# Chapter 5

## Towards a more comprehensive view of anger

The aim of this thesis was to investigate the role individual differences play in the experience of anger. This thesis investigated how individual differences in core personality traits affect one of the crucial precursors to anger (i.e. judgments of hostile intent), how core personality traits interact to predict the stable and chronic experience of anger (i.e. trait anger) and how this experience is expressed (i.e. Anger Expression-In, Anger Expression-Out, Anger Expression-Control), and whether trait anger and its expressions were related to variations in cortical gray matter.

The experience of anger has been examined through the lens of individual differences before (e.g. Anderson & Bushman, 2002; Ax, 1953; Fabiansson et al., 2012; Spielberger, 1988), however, there has been considerable variability in these results and several issues remained unclear: 1) how core personality traits interacted to predict the experience of anger, 2) how core personality traits predicted the cognitive processes underpinning judgments of hostile intent, and 3) how variation in regional gray matter related to the experience of anger. To this end, the current thesis attempted to address these gaps in the empirical literature. The following section provides a brief summary of the results related to the preceding empirical chapters, how these results relate more broadly to our current understanding of anger and its closely related constructs, limitations of the work presented here, and recommendations for further work.

## Summary of the main findings

### Chapter 2

Previous empirical work has identified several key findings related to how core personality traits predict the experience of anger (Jones, Miller, & Lynam, 2011). This prior research has consistently identified roles for the personality traits neuroticism (Hofmans et al., 2008; Tremblay & Ewart, 2005; Sharpe & Desai, 2001), agreeableness (Egan & Campbell, 2009; Graziano & Tobin, 2002; Hofmans et al., 2008; Meier & Robinson, 2004), and conscientiousness (Burton et al., 2007; Lee & Dow, 2011; Miller et al., 2012; Tremblay & Ewart, 2005), with some evidence for the roles of extraversion (Martin et al., 1999; Miller et al., 2012) and openness to experience (Bettencourt et al., 2006; Jones et al., 2011; Miller et al., 2012). More recent work has found that measuring for interactions amongst personality traits helps account for variability between these traits and the experience of anger (Jensen-Campbell et al., 2007; Ode et al., 2008). However, the work identifying these interactive effects has been conducted in student samples of modest size. Therefore, an investigation using a large and generalizable sample was justified. To this end, the investigation described in Chapter 2 used a large and generalizable sample to identify how interactions amongst core personality traits influenced the pathway towards trait anger and its expressions (i.e. Anger Expression-In, Anger Expression-Out, Anger Expression-Control).

Results presented in Chapter 2 reveal several expected direct effects of core personality traits on the pathway towards trait anger and its expressions. More importantly, several interactive effects, within core personality traits, were seen on the pathway towards trait anger, Anger Expression-Out (AX/Out), Anger Expression-Control (AX/C), and aggression. Specifically, conscientiousness moderated neuroticism's pathway towards AX/C and, in a three-way interaction, conscientiousness × agreeableness moderated

neuroticism's pathway towards trait anger, Anger Expression-Out, and aggression. These findings provide empirical support for the interactive effects depicted by prominent theoretical models of anger and aggression (DeWall et al., 2011; Slotter & Finkel, 2011; Wilkowski & Robinson, 2010).

**Chapter 3**

Appraising the actions of others as intentionally hostile is an important component within prominent models of anger (DeWall et al., 2011; Wilkowski & Robinson, 2008) and increases both the likelihood and intensity of anger (Berkowitz & Harmon-Jones, 2004). Surprisingly, little empirical attention has been given to identifying the latent or underlying factors influencing judgments of intent. To this end, the studies presented in Chapter 3 describe, firstly, how core personality traits relate to judgments of hostile intent and, secondly, how higher order processes (i.e. an inflated sense of self-entitlement, social projection of one's own characteristics) mediated the core personality trait honesty-humility's relationship with judgments of hostile intent. Both studies recruited online samples of people to provide ratings indicating the degree to which they agree that events depicted within hypothetical vignettes, adapted from previous studies (Combs et al., 2007; Tremblay & Belchevski, 2004), were committed intentionally. Participants also completed self-report measures of core personality traits (i.e. HEXACO, BFI) and metrics of potential mediators. Potential mediators were identified based on previous literature and included constructs of an inflated sense of self-entitlement (i.e. narcissistic-admiration), a sensitivity to being socially usurped (i.e. narcissistic-rivalry), and social projection of one's own characteristics (i.e. trustworthiness in others).

Results of parallel analyses presented in Chapter 3 indicate that, across two studies, ratings of intentionality on the hypothetical vignettes were influenced by two latent factors. These factors were tentatively interpreted as: 1) a sensitivity to the social or contextual

cues of intent contained within the text, and 2) the likelihood to make judgments of hostile intent. We are hesitant to firmly label these factors until further empirical work confirms their defining features. As suggested in the chapter's general discussion, further empirical investigations should make an effort to use a metric of judgments of hostile intent that attempts to capture transgressions occurring in multiple domains – e.g. moral, physical, social.

Across studies, core personality traits were modest predictors of the latent factors underlying participants' ratings of intentionality. Scores in Factor 1 were consistently predicted by HEXACO-conscientiousness across studies. Agreeableness (as measured by the BFI) was a predictor of scores in Factor 1, within Study 1. Honesty-humility, (low) agreeableness, conscientiousness, and openness to experience (as measured by the HEXACO) were predictors of scores in Factor 1, within Study 2, while scores in Factor 2 were predicted by conscientiousness. Regarding the proposed mediators, a lower score on the construct of a sensitivity to being socially usurped (measured by narcissistic-rivalry) was predictive of scores in Factor 1, while an inflated sense of self-entitlement (measured by narcissistic-admiration) and the social projection of one's own characteristics or tendencies onto others (measured by generalized trust in others) were predictive of scores in Factor 2, and both mediated honesty-humility's pathway towards scores in Factor 2.

As novel investigations (to the best of our knowledge), these studies provide observations into how core personality traits relate to judgments of hostile intent. Moreover, these results provide evidence for the mediating effects of an inflated sense of self-entitlement and the social projection of one's own characteristics on honesty-humility's relationship with the second factor, identified here, underlying judgments of hostile intent. The observations form the foundation for further investigations into the fundamental cognitive processes involved in judgments of hostile intent. However, results

indicated that core personality is, at best, only a modest predictor of judgments of hostile intent; metrics of narcissism and generalized trust appear to be more robust predictors.

**Chapter 4**

Numerous studies have investigated how relative activation within cortical regions associates with the likelihood of anger and aggression (see review above). However, very little attention has been given to identifying how volumetric variations of cortical gray matter (GM) associate with the experience and expressions of anger within a healthy (e.g. non-clinical, non-forensic) population. Considered to be where computational elements of cognition occur (Miller, Alston, & Corsellis, 1980), GM relates to performance across numerous cognitive tasks (Gur et al., 1999), suggesting its potential involvement in the cognitive aspects of anger. A thorough review and aggregation of the neuroimaging literature surrounding anger and its expressions provided a source with which to develop particular regions of interest for the investigation detailed in Chapter 4.The investigation used voxel-based morphometry (VBM) to examine whether regional volumes of cortical gray matter correlated with participants' scores on the State Trait Anger Expression Inventory (STAXI; Spielberger, 1996) metrics of trait anger, anger-in (AX/IN), anger-out (AX/Out), and anger-control (AX/C). Based on previous findings, a regions of interest map was created and included the periaqueductal gray (PAG) and the following bilateral regions defined by the AAL atlas extension (Tzourio-Mazoyer et al., 2002) for MarsBaR (Brett et al., 2002): amygdala, frontal inferior orbital, anterior cingulate, median cingulate, middle frontal gyrus, insula, frontal inferior gyrus – opercular part, frontal medial orbital, precentral gyrus, and thalamus. All locations used for the region of interest mask were chosen after their involvement in the experience of anger was corroborated by at least two prior empirical studies. It was surprising, then, that none of the effects related to these regions survived correction for multiple comparisons. In an exploratory step, a whole-brain

VBM analysis correcting for non-stationary was conducted to determine if any areas outside of the region of interest mask were significantly correlated.

Results from both the region of interest analysis and whole-brain analysis indicated that when using FWE correction (peak voxel threshold $p < .05$) as a nominal threshold to correct for multiple comparisons, no statistically significant correlations were seen between any of the STAXI scales and GM within the region of interest mask. However, several significant correlations were seen at the uncorrected level, and were reported for future reference and meta-analyses – in line with arguments presented by Lieberman and Cunningham (2009) and Poldrack and colleagues (2008). At an uncorrected level, scores on trait anger were positively associated with GM volume in the right ventrolateral prefrontal cortex; whole-brain analysis revealed no significant relationships. At an uncorrected level, scores on AX/IN was positively correlated with GM volume in the left insula, and negatively correlated with GM volume bilaterally in the precentral gyrus; whole-brain analysis revealed no significant relationships. At the uncorrected level, scores on AX/Out was positively correlated with GM volume in the left precentral gyrus and right dorsolateral prefrontal cortex, with no negative correlations; whole-brain analysis revealed no significant relationships. At the uncorrected level, scores on AX/C was positively correlated with GM volume in the left superior frontal gyrus and right orbitofrontal cortex, and negatively correlated with GM volume in the left medial prefrontal gyrus; whole-brain analysis revealed no significant relationships.

Scores on trait anger were positively correlated (uncorrected) with GM volume in a region associated with planning and executing long-term goals (i.e. right ventrolateral prefrontal cortex). Scores on AX/IN were positively related (uncorrected) to GM volume in a region responsible for homeostatic regulation, decision making in affective states, and directing affective expressions inward (i.e. left insula); scores were negatively related

(uncorrected) to regions involved in response inhibition (i.e. left and right precentral gyrus). Scores on AX/Out were positively correlated (uncorrected) with GM volume in an area associated with increased inhibitory control (i.e. left precentral gyrus, right dorsolateral prefrontal cortex). Scores on AX/C were positively correlated (uncorrected) with GM volume in a region associated with emotional regulation (i.e. left superior frontal gyrus) and a region associated with the appraisal of social-emotional stimuli (i.e. right orbitofrontal cortex); a negative correlation (uncorrected) was seen in relation to a region associated with inhibitory control (i.e. left medial prefrontal gyrus).

Several of the identified relationships demonstrated effects, at the uncorrected level, in agreement with previous findings. For example, it was of little surprise that scores on AX/IN – with anger being an increase in physiological functioning – were positively related to GM volume in a region implicated in general homeostatic control and directing the expression of affective states inward (i.e. left insula). Similarly, scores in AX/C positively related to GM volume in regions associated with inhibitory control and emotional regulation (i.e. left superior frontal gyrus), and the appraisal of emotions (i.e. right orbitofrontal cortex).

Notably, several of the results that were reported, at the uncorrected level for future reference and meta-analyses, demonstrated effects in a direction opposite to what would have been expected had this investigation not been exploratory. For example, we were at a loss at trying to explain why scores on trait anger – the experience of which is often in conflict with or distracting from overall goals – were positively related to a region implicated in maintaining and fulfilling long-term goals. Similarly, we were unable to explain why scores on AX/Out were positively related to regions associated with behavioural and affective inhibitory control. Since what is understood about the relationship between regional GM volume and function is still somewhat unclear, these

results suggest that further work be conducted to establish the nature of the relationship between the STAXI scales and regional GM volume.

This investigation was an attempt to identify the relationships that exist between regional GM volume and the experience and expressions of anger in a healthy adult population. Despite the analyses' regions of interest having been implicated in the experience of anger by prior empirical work, no effects seen here were strong enough to survive corrections for multiple comparisons – leading us to be largely agnostic towards regional GM volume's role in the experience of anger. Nonetheless, following guidelines laid out by previous work, we report relationships that were seen to be significant at the uncorrected level so that they may be referred to for future work and meta-analyses. As stated above, further work in this area should focus on attempting to clarify the relationship between regional GM volume and function. Additionally, consideration should be given to using an analytic method that accounts for cortical thickness. VBM analysis, while a valid technique, overlooks the relationship between cortical GM volume and cortical thickness.

## Implications for future work

The goal of this thesis was to advance what is currently understood about the individual differences related to anger. To this end, this thesis presents investigations into how individual differences in core personality traits relate to the experience and expression of anger, how individual differences in core personality traits relate to the cognitive process(es) involved in judging events to be intentionally hostile, and finally how regional GM volume relates to trait anger and its expressions. These studies highlight several key concepts contained within this thesis.

Firstly, personality traits function as direct predictors of not only anger, but also anger-related expressions. While numerous studies have reported on associations between core personality traits and broadly defined anger (e.g. Egan & Campbell, 2009;Sharpe & Desai, 2001; Tremblay & Ewart, 2005), we are only aware of one other study (i.e. Martin et al., 1999) examining the facets of anger through the lens of Spielberger's STAXI (1996). The STAXI, compared to other measures such as the Aggression Questionnaire (Buss & Perry, 1992), allows for a more comprehensive measure of anger – capturing expression styles, in addition to trait anger. We present evidence that different styles of anger expression relate to distinct factors. For example, (low) extraversion scores were the strongest predictor of the tendency to direct anger inwards (i.e. AX/IN), yet they were not significantly related to levels of trait anger. These results indicate that studies examining only one facet of anger – typically trait anger – are overlooking other important and statistically significant relationships. Since the various facets of anger captured by the STAXI relate differentially to long-term outcomes such as general health (Martin et al., 1999), identifying the core personality factors that most strongly relate to the individual facets of anger will allow for a greater understanding of how core personality influences constructs predictive of long-term outcomes.

Secondly, interactions amongst personality traits should be considered more often during investigations into individual differences. Results in Chapter 2 indicated that moderating effects, between personality traits, were present and had a significant impact on scores related to trait anger, AX/Out, and AX/C. For example, conscientiousness was seen to be a significant influence in both 2-way and 3-way moderation models. While laying out their theory of the Five Factor Model, McCrae and Costa (1999) acknowledge the moderating effects related to personality traits. Simply put, conscientiousness and agreeableness have been theorized to have evolved as cognitive traits designed to inhibit the reactivity typically associated with impulsive and automatic emotionality (i.e.

neuroticism; Eisenberg, 2005; Metcalfe & Mischel, 1999; Rothbart, Posner, & Kieras, 2006). With results from multiple studies (i.e. Jensen-Campbell et al., 2007; Ode et al., 2008; Pease & Lewis, 2015) finding support for the moderating roles of conscientiousness and agreeableness, future work should examine for interactive effects amongst personality traits when theoretically justified. McCrae and Costa (1999) also highlight the dynamic processes occurring between basic tendencies (i.e. personality traits) and higher-order characteristic adaptations (i.e. "attitudes"). Results from Chapter 3 provide evidence in support of this model. These results indicated that higher-order adaptations (i.e. an inflated sense of self-entitlement, social projection of one's of tendencies) mediated a lower-order (i.e. trait honesty-humility) construct's pathway towards judgments of hostile intent. Taken together, results from Chapter 2 and Chapter 3 present evidence for why future investigations should attempt to anticipate and statistically identify potential interactive effects.

Thirdly, any correlations between neuroarchitecture and anger may extend beyond the reach of VBM. Results presented in Chapter 4 indicated that while some correlations between scores on facets of anger and regional GM volume trended towards significance, they were unable to survive the more stringent corrections for multiple comparisons. For reasons detailed above, these results were still reported and should not entirely be excluded from further consideration. However, the relationship between neuroarchitecture and anger may relate more to elements not captured by the VBM analysis: cortical thickness and white matter integrity. Within clinical cohorts, aggression and antisocial behaviour – both constructs being closely related anger – have both been associated with reductions in cortical thickness (Fahim et al., 2011; Strenziok et al., 2011) and disruptions to regional connectivity formed by white matter tracts (Hoptman, 2003; Hoptman et al., 2010). Future investigations into the relationship between neuroarchitecture and anger within healthy

participants should incorporate these elements into relevant analyses, without wholly discounting results reported in Chapter 4.

## Conclusion

In summary, across four studies, this thesis presents several noteworthy results. Firstly, in a nationally-representative sample, core personality traits were seen to be predictors of trait anger and its expressions. More importantly, however, when interactive effects between trait neuroticism, conscientiousness, and agreeableness were included in the analysis, a more comprehensive and dynamic understanding of the processes underlying multi-faceted anger became apparent. Secondly, in a novel investigation into how core personality relates to judgements of hostile intent, two latent factors influencing participants' ratings of intentionality were identified and replicated in a second study, core personality was seen to predict participants' factor scores within the two latent factors, and the higher-order constructs of an inflated sense of self-entitlement and social projection have on the core personality trait honesty-humility's pathway towards the second of the latent factors. Finally, an examination of the neuroarchitecture related to trait anger and its expressions revealed that no correlations were significant following corrections for multiple comparisons. In conclusion, the studies presented in this thesis contribute to the literature and understanding of anger by supporting previous works' findings related to personality traits acting as predictors of anger and its expressions, identifying the importance of analyzing interactive effects present between traits on their pathway towards anger and its expressions, and challenging the assumption that variation in regional GM volume will associate with variation in participants' levels of trait anger or its expressions.

# Appendices

## Appendix A – Judgments of Hostile Intent Hypothetical Vignettes

1. Someone jumps in front of you on the grocery line and says, "I'm in a rush." You end up dropping some things on the floor.

2. A friend of yours slips on the ice, knocking you to the ground.

3. You've been at a new job for three weeks. One day, you see one of your new co-workers on the street. You start to walk up to this person and start to say hello, but she/he passes by you without saying hello.

4. While walking outside during the rain a car swerves and drives into a puddle splashing water onto you.

5. You have an appointment with an important person. When you arrive at your appointment, the secretary informs you that the person is not in; they took the day off.

6. You are on a bus sitting in an aisle seat. A person gets on the bus at the next stop, begins walking as the bus moves, and steps on your foot.

7. Your neighbors are playing loud music. You knock on the door and ask them to turn it down. Fifteen minutes later, the music is loud again.

8. You walk past four teenagers playing tennis. As you pass them you hear one start to laugh, then the tennis ball hits you in the head.

9. You and a friend are at a bar and you both leave your table briefly, leaving your jackets on the seats, to get some food and drinks. When you return, you notice that two strangers are sitting in your seats. Your friend politely explains to them that you have been sitting there, but they tell you ‘‘That’s too bad, go find another table.’’

10. You are supposed to meet a new friend for lunch at a restaurant but she/he never shows up.

11. You’ve been looking for a parking spot for a while, when you see one up ahead. You put your signal on, proceed toward the spot, but someone passes your car and takes the parking space.

12. You’re dancing at a club and someone bumps into you from behind.

13. You call a friend and leave a message on their voice mail, asking them to call you back. One week passes and they have not called you back.

14. You’re at a bar watching a football game and having a drink. Suddenly, the home team scores, people begin to cheer, and someone hits your arm, spilling the drink onto your clothes.

15. You are at work trying to finish a project. You see your colleague, who was supposed to be helping you, on the telephone. Your colleague has been talking for over half an hour with a friend. You ask them for some help but they tell you to get lost.

Accidental: 2, 4, 6, 12, 14; Ambiguous: 3, 5, 8, 10, 13; Intentional: 1, 7, 9, 11, 15

**Appendix B – Full correlation matrix of Chapter 3 Study 1 variables.**

| Measure | H | E | X | A | C | O | BFI-O | BFI-C | BFI-E | BFI-A | BFI-N | Gender |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | | | | | | | | | | | | |
| E | -.09 | | | | | | | | | | | |
| X | .05 | -.21* | | | | | | | | | | |
| A | .25** | -.16 | **.28** | | | | | | | | | |
| C | .18* | -.12 | **.34** | .17* | | | | | | | | |
| O | .04 | -.03 | .17* | .00 | .12 | | | | | | | |
| BFI-O | .01 | -.01 | .26** | .04 | .23** | **.80** | | | | | | |
| BFI-C | .23** | -.10 | **.48** | **.27** | **.75** | .00 | .10 | | | | | |
| BFI-E | .00 | -.09 | **.79** | .08 | .17* | **.31** | **.36** | **.29** | | | | |
| BFI-A | **.35** | .05 | **.37** | **.74** | **.39** | .09 | .14 | **.46** | .22** | | | |
| BFI-N | -.19* | **.56** | **-.56** | **-.55** | **-.35** | -.05 | -.05 | **-.53** | **-.29** | **-.50** | | |
| Gender | .18* | **.39** | .01 | -.03 | .06 | -.02 | -.03 | .11 | .06 | .17* | .18* | |
| Age | .18* | -.08 | -.03 | .09 | .16 | -.15 | -.16 | .18* | -.01 | .03 | -.18* | -.02 |

Note: H = honesty-humility; E = emotionality; X = extraversion; A = agreeableness; C = conscientiousness; O = openness to experience; BFI-O = BFI openness; BFI-C = BFI conscientiousness; BFI-E = BFI extraversion; BFI-A = BFI agreeableness; BFI-N = BFI neuroticism; Gender: Male = 1; Gender: Female = 2; Bolded = p<.001; ** p<.01; *p<.05.

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