




## Empirical Article

**Trait continuity: Can parent-rated infant temperament predict HEXACO personality in early adulthood?**SVIATLANA KAMAROVA,<sup>1</sup>  PATRICK D. DUNLOP<sup>2</sup>  and SHARON K. PARKER<sup>2</sup> <sup>1</sup>*Curtin School of Population Health, Curtin University, Bentley, WA, Australia*<sup>2</sup>*Future of Work Institute, Curtin University, Bentley, WA, Australia*Kamarova, S., Dunlop, P. D. & Parker, S. K. (2023). Trait continuity: Can parent-rated infant temperament predict HEXACO personality in early adulthood? *Scandinavian Journal of Psychology*, 64, 512–526.

Examining the Raine cohort study, we tested the trait continuity hypothesis by examining the extent that young adults' (25–29 years old) self-reported HEXACO personality can be statistically predicted from multi-dimensional parental temperament ratings collected in infancy (1–2 years old). The study incorporated a lagged design (two waves), a large sample size ( $n = 563$ ), and examined both temperament and personality as both dimensions and profiles. Overall, we found very limited evidence of trait continuity, with generally very weak and few statistically significant observed associations of infant temperament with early adulthood personality. Relations were weak whether profile or dimension-based operationalizations of both phenomena were adopted. Additionally, controlling for sex affected the relations of temperament and personality only to a small extent for most of the traits, and moderation effects of sex were generally zero-to-trivial in size. Altogether, parent-rated temperament in infancy seems to provide little information about HEXACO personality in early adulthood.

**Key words:** Infant temperament, HEXACO, trait continuity, personality, development.

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People vary in terms of their basic, relatively stable preferences, and behavioral tendencies and these individual differences are noticeable throughout the entire life course, from infancy to old age. When studying younger people, these types of individual differences are often conceptualized by researchers as “temperament,” which represents genetic predispositions to respond during interactions with the environment. By contrast, as people mature into young adulthood and beyond, researchers typically conceptualize these types of individual differences as “personality,” which represents both biological predispositions and socially learnt behavior (Jang, Livesley & Vernon, 1996; Vukasović & Bratko, 2015). Personality and temperament are both thought to share a common core or origins (e.g., Buss & Plomin, 1984; Costa, McCrae & Löckenhoff, 2019), providing the grounds for a “trait continuity hypothesis,” that is, a relative stability in individual differences throughout the lifespan. Indeed, correspondence between infant temperament and adult personality has been found (Bornstein, 2014; Shiner & DeYoung, 2013), however, we note that due to the many obvious methodological challenges, many studies of the connection of infant or toddler temperament to adult personality are limited. For example, some studies follow only relatively short periods of life (e.g., Deal, Halverson, Havill & Martin, 2005; Hagekull & Bohlin, 2003), others measure temperament and personality simultaneously in childhood or adolescence using parent- or self-reports (e.g., Farrell, Brook, Dane, Marini & Volk, 2015; Grist & McCord, 2010), and others relate temperament to *future expected* personality through teacher or parent-rating (e.g., Graziano, Jensen-Campbell & Sullivan-Logan, 1998). Ultimately, to evaluate the trait continuity hypothesis requires more longitudinal evidence. Further, relatively little is known about the links between temperament and adult personality when the latter is

viewed through the lens of the HEXACO personality model. This study fills these gaps by investigating the relations of temperament, parent-reported at ages 1–2 and HEXACO personality self-reported at ages 26–29 in a sample of Western Australian adults born in the late 1980 s (the Raine study; Straker, Mountain, Jacques *et al.*, 2017).

## PERSONALITY AND TEMPERAMENT

Personality can be defined as a unique and relatively stable pattern of individuals' behaviors, emotions, and thoughts (Costa *et al.*, 2019; Kern, Della Porta & Friedman, 2014) and individuals' abilities to adapt (Cloninger, 2004; Hudson, Briley, Chopik & Derringer, 2019; Hudson & Fraley, 2015). Temperament is thought to represent a set of psychobiological genetic predispositions that drive the automatic associative responses to emotional stimuli (Cloninger, 1994). Whereas temperament remains the “core” for personality development (Rothbart & Bates, 2006), non-biological factors through life experiences are thought to interact and integrate with temperament, ultimately forming personality (e.g., Cloninger, 2004; Shiner & DeYoung, 2013). Research has determined that temperament has moderate to high heritability (e.g., Cloninger, Cloninger, Zwir & Keltikangas-Järvinen, 2019; Loehlin, 1992; Saudino, 2012; Vandermeer, Sheikh, Singh *et al.*, 2018) and is developmentally stable throughout the lifespan (Anusic & Schimmack, 2016; Bornstein, Hahn, Putnick & Pearson, 2019; Kopala-Sibley, Olino, Durbin, Dyson & Klein, 2018; Neppl, Donnellan, Scaramella *et al.*, 2010). Similarly, meta-analytic evidence suggests that major dimensions of personality have substantial heritability (Vukasović & Bratko, 2015), and genome-wide association studies have

suggested there are sizeable polygenetic contribution to personality traits (Zwir *et al.*, 2020). Thus, while both temperament and personality encompass the same basic or conceptual traits that are hard to differentiate empirically (McCrae, Costa, Ostens *et al.*, 2000; Shiner & DeYoung, 2013), temperament appears not to be a simple deterministic precursor to personality, as it remains clear that environmental factors can influence both (De Pauw, 2016).

### *The structure of temperament*

The Thomas and Chess (1977) model of temperament, which is the framework used in this study, proposed that children's individual differences have an endogenous basis. Based on content-analyzed data collected from interviews about tendencies observed in infants, Thomas and Chess (1984) identified nine temperament dimensions: activity, mood, approach/withdrawal, adaptability, rhythmicity, intensity, persistence, distractibility, and threshold of responsiveness. These authors suggested that different combinations of these traits biologically predispose children's individual differences in terms of the quality of interactions with environment and their adjustment ability. Identifying these combinations has been instrumental in linking temperament to behavioral problems (e.g., Mervielde & De Pauw, 2012), whereas the original dimensions have been used to identify predictors of personality traits.

Modified from the Thomas and Chess model and based on slightly different conceptualizations of temperament, some alternative models proposed higher order factors of temperament. Specifically, Rothbart (1981, 2012, 2019) defined temperament as a function of "constitutional" differences in reactivity and self-regulation, Buss and Plomin (1975, 1984) conceptualized temperament as "inherited traits present in early childhood", and Goldsmith and Campos (1982) believed that emotions drive observed behavioral tendencies. De Pauw, Mervielde and Van Leeuwen (2009) argued that the different models provide unique contributions that complement one another. To examine consistency of the temperament structures between different models throughout the childhood, Mervielde and De Pauw (2012) conducted correspondence analysis.<sup>1</sup> Age-specific analyses revealed a "declining convergence between temperament models with increasing age... [which could be] attributed to the age-related expansion of the child's behavioral repertoire" (Mervielde & De Pauw, 2012, p. 32). Overall, there appears to be a conceptual and empirical overlap between many of the dimensions among the temperament models, though they also extend one another (a summary is provided in Table S1 in the supplemental material).

The Thomas and Chess model of temperament has been the foundation for development of several temperament assessment tools. However, the measures are sometimes criticized for a "lack of independence of items and dimensions" and "unknown factorial organization across developmental periods" (Reynolds & Fletcher-Janzen, 2007, p.1983). In particular, while the Thomas and Chess model proposes that there exist nine dimensions of temperament, various infant studies have put forward empirical evidence of five (Sanson, Prior, Garino, Oberklaid & Sewell, 1987), six (Sanson, Smart, Prior, Oberklaid &

Pedlow, 1994), seven (Bohlin, Hageküll & Lindhagen, 1981; Sanson *et al.*, 1994; Sasaki, Mizuno, Kaneko, Murase & Honjo, 2006), eight (Hageküll, Lindhagen & Bohlin, 1980). Similar conclusions were found for child temperament across ages (e.g., Barger, Moody, Ledbetter, D'Abreu, Hepburn & Rosenberg, 2019; Martin, Wisenbaker & Huttunen, 1994).

In our investigation, we adopt the nine-dimensional approach originally proposed in their Thomas and Chess model, however due to the uncertainty (Martin *et al.*, 1994) and instability (Mervielde & De Pauw, 2012) of the temperament structure, we also derived an alternative measurement model using exploratory factor analytic methods as supplemental analyses. Further, we also recognize that Thomas and Chess (1977) also proposed that temperament can be studied through the lens of types (or profiles), and these authors had identified three such profiles that can be derived from the dimension scores: easy, slow to warm up, and difficult. Two intermediate profiles (low, or closer to easy, and high, or closer to slow to warm up) were later introduced to classify those who did not fit into the three original types (Carey & McDevitt, 1978). In line with this approach, and in recognition of recent neuropsychological and psychophysiological research (Moreira, Inman & Cloninger, 2021), we also examined a profile-based approach using the five-profile framework.

### *The structure of personality*

Until relatively recently, the dominant view based on early lexical research was that personality is best summarized in terms of five major dimensions (e.g., Goldberg, 1990; Saucier, 2019), later termed the Big Five (B5) or its close relative, the Five Factor Model<sup>2</sup> (Goldberg, 1990; Goldberg & Saucier, 1998). However, later analyses of lexical studies, led by Ashton, Lee and their colleagues (e.g., Ashton, Lee, Perugini *et al.*, 2004), subsequently identified a robust six-factor model, which was since labeled HEXACO. The HEXACO and B5 models share three factors in common, extraversion (X), conscientiousness (C) and openness to experience (O) but thereafter the two models diverge. First, the configuration of the HEXACO's agreeableness (A) and emotionality (E) axes is different from that of the B5's agreeableness and emotional stability. Whereas the B5's emotionality stability dimension captures variance pertaining to the tendency towards anger, that variance is represented by HEXACO's A dimension. Conversely, B5's agreeableness factor incorporates sentimentality content that is captured by HEXACO's E dimension (Ashton, Lee & de Vries, 2014). Second, content from the HEXACO model's additional dimension honesty-humility (H) is largely absent from some measures of the B5 or captured by A in other measures (Ashton *et al.*, 2014). This dimension captures the proclivity for honesty, straightforwardness, and modesty versus deception, greed, and pretentiousness. Because of its distinctiveness in the HEXACO model, and the relative recency of the model's emergence, little is known about the genesis of the H factor or its relationship with early childhood factors. Nonetheless, as recent meta-analyses have revealed, the H factor is important for understanding tendencies to engage in a range of exploitative behaviors such as unethical decision-making, the absence of active cooperation in economic games, and

engagement in counterproductive or anti-social behavior in various settings (Zettler, Thielmann, Hilbig & Moshagen, 2020).

In contrast to studies of temperament, profile-based or person-centered approaches to assessing personality are relatively rarer (though see Asendorpf, Borkenau, Ostendorf & Van Aken, 2001; Caspi & Silva, 1995; Robins, John, Caspi, Moffitt & Stouthamer-Loeber, 1996). Nonetheless, a recent large-sample investigation adopting the HEXACO model of personality discovered evidence that five distinct configurations (Achievement-Oriented Agentic, Ego-Oriented Agentic, Insecure, Communal, and Socially Adjusted) could be robustly identified (Espinoza, Daljeet & Meyer, 2020). In the main investigation, we adopt the more common dimensional approach to operationalizing personality, however, we also present analyses involving personality profiles in a supplemental document.

#### THE TRAIT CONTINUITY HYPOTHESIS: FROM TEMPERAMENT TO PERSONALITY

As discussed above, both temperament and personality incorporate a non-trivial genetic component. The concept of temperament itself reflects biologically based predispositions, whereas the views regarding the extent of the influence of genetic factors on personality traits varies from “pure” heritability (e.g., Loehlin, 1992) to predominantly (or moderately) endogenous, allowing for a contribution of environment to their formation (McCrae *et al.*, 2000). Supporting the perspective of differentiation between regulative and integrative aspects of personality, some personality traits were initially found to be more genetically based (e.g., neuroticism and extraversion; Eysenck, 1990; Kandler, Held, Kroll, Bergeler, Riemann & Angleitner, 2012), with others were relatively weakly linked to genetics (i.e., openness, agreeableness, and conscientiousness; Kandler *et al.*, 2012). Sanchez-Roige, Gray, MacKillop, Chen and Palmer (2018) undertook a review of both twin and family studies and concluded that heritability was relatively consistent across personality inventories, especially estimates derived from twin studies, albeit estimates garnered from adoption studies were lower than those from family and adoption studies when compared to twin studies. Vukasović and Bratko’s (2015) meta-analysis concluded that the heritability estimates for the B5 traits are roughly equal, ranging from 0.31 (conscientiousness) to 0.41 (openness), with confidence intervals for each overlapping the point estimates of the others. By contrast, Sanchez-Roige *et al.*’s (2018) review of genome-wide association studies (GWAS) found that genetic associations were strongest for neuroticism (up to 15.7%) and extraversion (up to 18.1%), while less often and less consistency was found for openness (10.7% and 21%, respectively; Lo, Hinds, Tung *et al.*, 2017; Power & Pluess, 2015), conscientiousness (9.6%; Lo *et al.*, 2017) and agreeableness (8.5%; Lo *et al.*, 2017). Therefore, in contrast to the heritability estimates that appear relatively consistent across the B5 (Vukasović & Bratko, 2015), the evidence from gene studies reviewed by Sanchez-Roige *et al.* (2018) may suggest that some of the B5 have stronger biological bases than others. Nonetheless, collectively, the evidence seems relatively clear: the major dimensions of personality have a biological basis but are not completely explained by it.

Further, according to a recent neurobiological perspective, the individual personality traits are genetically heterogeneous and reflect complex molecular neuropsychological mechanisms that can be distinguished only when a person is considered as a whole, implying a profile- or person-centered rather than dimensional lens should be taken (Cloninger *et al.*, 2019; Zwir *et al.*, 2020). This line of research has revealed that the genetic links are present for both temperament and personality profiles, while their underlying mechanisms associated with different systems of learning and memory (Cloninger & Zwir, 2018). Whereas temperament depends on the procedural system (associative conditioning of habits and skills), character (the self-regulatory component of personality) depends also on semantic and noetic learning systems associated with the learning facts and personal narratives (Cloninger, Abou-Saleh, Mrazek & Moller, 2011). Given that temperament can be defined as neurochemically-based individual differences in the regulation of formal dynamical aspects of behavior (Trofimova, Robbins, Sulis & Uher, 2018), Cloninger *et al.* (2019) argued that molecular processes that regulate associative conditioning account for heritability of human temperament, and found that three Thomas and Chess-based temperament profiles were linked to three profiles of individual differences later in life. Specifically the “easy” temperament profile was associated with “reliable” profile in adulthood, characterized by high conscientiousness, extraversion, ability for self-control/regulation in activity and high warmth and low emotional intensity, the “difficult” temperament profile was linked to the “sensitive” adult profile with neurotic characteristics, such as pessimisms, fearfulness, emotional instability, and hypersensitivity, lack of self-control in activity; and the “antisocial” temperamental profile (i.e., “slow to warm”) corresponds to socially detached adults, with low care for others, and high impulsivity and easy-to-discouraged and antisocial maladaptive conduct. These relationships are proposed to be supported by learning (i.e., associative conditioning). Therefore, in line with Cloninger *et al.*’s (2019) conclusion, we also support their position that both individual dimensions and multidimensional profiles have complementary utility.

Another reason to anticipate trait continuity from temperament to personality is the high observed stability of personality traits, demonstrated in longitudinal research (e.g., Anusic & Schimmack, 2016; Chopik & Kitayama, 2018; Costa *et al.*, 2019). Anusic and Schimmack (2016) in their meta-analysis of 243 retest coefficients for personality traits revealed that the 15-year stability is approximately 0.60. Moreover, the rank-order stability within a cohort tends to remain high over time (e.g., Costa *et al.*, 2019; McCrae *et al.*, 2000; McCrae, Costa & Busch, 1986). Further, certain environmental factors (e.g., acute traumatic life events) can cause changes in traits (e.g., neuroticism), however, these changes tend to be relatively short-term, with the personality returning to “normal” after some time (Costa *et al.*, 2019). Although research is still emerging, it appears that some chronic environmental factors may affect personality more permanently, however (e.g., Jeronimus, Riese, Sanderman & Ormel, 2014; Ormel, Riese & Rosmalen, 2012; Wu, Wang, Parker & Griffin, 2020). Further to the above, the effects of environments can also be partly accounted by the people’s *selection* (intentional or otherwise) of such environments;

that is, our traits influence the environments we pursue which, in turn, can reinforce those traits (e.g., Bronfenbrenner & Morris, 2006; Neyer & Asendorpf, 2001; Tett & Guterman, 2000).

Third, empirically, temperament also appears to be somewhat stable over time, though not to the same extent as personality. Indeed, temperament trait stability can be observed as early as infancy (Bornstein, 2014; Bornstein *et al.*, 2019). According to a meta-analytic study conducted by Roberts and DelVecchio (2000), rank-order stability of temperament increases with age, but even in infancy, test–retest correlations of around 0.35 have been observed. Likewise, according to some research a global core factors such as self-regulation underly both temperament and personality (Denissen, van Aken, Penke & Wood, 2013), advocating for the existence of the trait consistency.

#### ASSOCIATIONS OF TEMPERAMENT WITH PERSONALITY

Although previous research has investigated the associations of temperament with personality, synthesizing the findings is challenging because of: (1) the use of varying temperament and personality models; (2) the use of varying measures of both; (3) variability in sample characteristics (such as the ages in which temperament and personality are measured); (4) dissimilar study designs (cross-sectional/concurrent measurement vs. longitudinal/cohort); (5) in the case of longitudinal designs, variable timing between the measurement of temperament and personality; and (6) the variety of reporting sources of the temperament and personality variables (parent, teacher, caregiver, vs. self-report, and single-source vs. multi-source). Further, many of the few published longitudinal or lagged studies that we were able to identify appear not to have achieved large sample sizes.

Altogether, these variable study features are associated with a wide range of conclusions regarding the strength of associations between temperament and personality. In the present study, temperament was parent-rated when the participant was aged around one year, and personality was self-rated between ages 25–29. Accordingly, rather than seek to summarize the entire body of work examining the links between temperament in early childhood and personality in adulthood, here we focus our empirical review on the findings of other studies with longitudinal or lagged designs. We are aware of ten such studies (see Table S2 for a summary).

First, Deal *et al.* (2005) measured temperament, via non-parent caregiver-report (teacher, daycare provider), among 115 children aged between 3 and 6 (mean age = 4.59 years), and parent-reported child personality approximately 12 years later (mean age = 17.98). We note that the age at which temperament was collected is considerably older than in our study. Deal *et al.* (2005) found that impulsivity and inhibition as expressions of self-regulation processes in children were both negatively associated with B5 (NEO-FFI) agreeableness ( $B = -0.28$ ,  $B = -0.19$ , respectively). Impulsivity (positively) and inhibition (negatively) temperament dimensions were also associated with openness to experience, but only among the males ( $B = 0.30$ ,  $B = -0.28$ , respectively). Impulsivity was also negatively related to conscientiousness ( $B = -0.33$ ) and positively to neuroticism

( $B = 0.27$ ), whereas inhibition was negatively associated with extraversion ( $B = -0.29$ ).

Second, within a large longitudinal project, the Fullerton Study, Guerin, Gottfried, Oliver and Thomas (2003) collected parent-rated temperament measure from a sample of 107 people, repeatedly, every six months from ages 1 to 5, and yearly thereafter, and self-rated personality at 17.<sup>3</sup> In this study, data accumulated from the repeated measures of temperament were transformed into two sets of single indicators for each temperament dimension, from infancy to middle childhood and throughout adolescence. Here, we focus on the indicators of early childhood temperament dimensions and their links to personality traits observed at 17 years. Task orientation and flexibility (two dimensions that included items from original Thomas and Chess study “persistence,” “distractibility,” and “adaptability”) were negatively related to neuroticism in adulthood ( $r = -0.22$ ) and positively related to conscientiousness ( $r = -0.22$ ). The approach dimension was positively related to extraversion ( $r = 0.30$ ), openness to experience ( $r = 0.20$ ), agreeableness ( $r = 0.24$ ). The flexibility dimension (that mainly represented “adaptability”) was negatively associated with neuroticism ( $r = -0.24$ ). Finally, conscientiousness was negatively associated with activity level (general) ( $r = -0.20$ ) and positively with rhythmicity (habits;  $r = 0.23$ ).

Third, from the Uppsala Longitudinal Study, we identified two papers examining the links between early temperament and personality, though we note personality was measured at age 9 rather than in adulthood. In Hagekull and Bohlin’s (2003) study, ratings of 93 participants’ temperament on five dimensions were collected from both parents at age 20 months, along with parent- and teacher-ratings of personality (age 9). In that study, both *activity* and *sociability* were positively related to extraversion ( $r = 0.26$ , and  $r = 0.23$ ). Hagekull and Bohlin (1998) adopted a slightly different approach in their analyses by aggregating multiple measurements of temperament via parent-reports at 28, 37, 43, and 51 months to form single indicators for each temperament dimension. That analysis revealed that emotionality was positively linked to neuroticism ( $r = 0.25$ ). Activity was positively associated with extraversion ( $r = 0.37$ ) and openness to experience ( $r = 0.22$ ), and negatively related to agreeableness ( $r = -0.29$ ). Sociability was positively related to extraversion ( $r = 0.33$ ) and openness to experience ( $r = 0.21$ ). Impulsivity was positively related to neuroticism ( $r = 0.28$ ) and negatively to agreeableness ( $r = -0.30$ ). Finally, shyness was negatively linked to extraversion ( $r = -0.38$ ) and openness to experience ( $r = -0.25$ ), and positively to agreeableness ( $r = 0.23$ ) and conscientiousness ( $r = 0.25$ ). Again, we note the relatively older age at which temperament was measured, and the younger age at which personality was assessed.

Fourth, in a sample of 83 participants, Blatny, Jelinek and Osecka (2007) assessed temperament through expert judges using the Brunet–Lezin test at ages 12, 18, 24, and 30 months and personality at age 38–44 years. The results revealed that only child disinhibition showed a significant link to adult’s personality: it was positively linked to extraversion ( $r = 0.25$ ).

Fifth, two papers based on participants from the Dunedin Study used an expert-rating approach to measuring temperament by having experts to assign children into five different temperament



types according to their behavioral responses assessed at age 3. The authors of these papers (Caspi and colleagues) examined the correspondence of these types with personality in adulthood.<sup>4</sup> Caspi, Harrington, Milne, Amell, Theodore & Moffitt (2003) examined the differences between the age 3 temperament groups and self-reported personality at age 26 in a sample of 1,019 participants. They found that “inhibited” children were the most conscientious in adulthood ( $z = 0.17$ ) but the least extroverted ( $z = -0.23$ ). Children in the “confident” temperament group grew up as more extraverted adults ( $z = 0.13$ ) whereas “reserved” children became introverted (low extraversion scores;  $z = -0.11$ ). Finally, the “under-controlled” group later developed personality profiles with higher neuroticism ( $z = 0.30$ ), and lower agreeableness ( $z = -0.34$ ), lower conscientiousness ( $z = -0.35$ ), lower openness to experience ( $z = -0.34$ ), and lower extraversion ( $z = -0.08$ ). An earlier study included the same participants and measures of temperament but examined self-reported personality at age 21, though this study did not use the B5 model of personality (Caspi & Silva, 1995). At 21 years of age, participants earlier classified as “under-controlled” scored higher on measures of impulsivity (i.e., reversed control;  $z = 0.20$ ), danger seeking (i.e., reversed harm avoidance;  $z = 0.23$ ), aggression ( $z = 0.19$ ), and interpersonal alienation ( $z = 0.36$ ); participants with an “inhibited” temperament style scored low on measures of impulsivity ( $z = -0.17$ ), danger seeking ( $z = -0.43$ ), aggression ( $z = -0.34$ ), and social potency ( $z = -0.33$ ); “confident” style was positively linked to impulsivity ( $z = 0.14$ ); “reserved” style was negatively associated to social potency ( $z = -0.14$ ); and “well-adjusted” style to normative or average scores.

Sixth, Slobodskaya and Kozlova (2016) examined the longitudinal relations of parent-rated temperament at approximately 8 months of age with children’s personality traits at 8 years, among 98 children. The findings revealed the associations between self-regulation at 7 months and extraversion ( $b = 0.24$ ), conscientiousness ( $b = 0.27$ ) and neuroticism ( $b = -0.31$ ), while negative mood was related to neuroticism ( $b = 0.22$ ).

Seventh, in a study of 109 participants, Tang, Crawford, Morales, Degnan, Pine and Fox (2020) measured a behavioral inhibition facet of temperament through a performance task at age 14 months, and three self-reported extraversion-related aspects of personality at age 26. These researchers found that participants who demonstrated high inhibition in toddlerhood grew up to be more reserved and introverted ( $\beta = 0.34$ ) and less socially active with friends and family ( $\beta = -0.23$ ). Inhibition was also positively linked to anxiety and depression ( $\beta = 0.20$ ).

Eighth, the Norwegian “Tracking Opportunities and Problems” (TOPP) study included 939 children, whose mothers assessed their children’s shyness at ages of 1.5, 2.5, 8.5, and 12.5 using Buss and Plomin’s (1984) measure, while self-report B5 personality traits were assessed at 16.5 years (Baardstu, Coplan, Karevold, Laceulle & von Soest, 2020). These authors found a weak association between early childhood shyness and adolescent extraversion, emotional stability, and openness to experience (for 1.5 year:  $r = -0.16$ ,  $-0.16$ , and  $-0.11$ ; for 2.5 years:  $r = -0.17$ , ns.,  $-0.14$ , respectively).

Nine, Wright and Jackson’s (2022) very recent study, based on a sample of 7,081 from the National Longitudinal Study of Youth

1979 showed evidence on the associations between temperament using Rothbart’s model measured through maternal report at age of  $3.76 \pm 2.01$  and B5 Personality measured in adolescence and/or young adulthood ( $M_{\text{age}} = 23.20 \pm 4.68$ ; ranging between 15 and 35). The findings showed small associations between temperament and personality traits. The strongest link was found between child’s insecurity and higher levels of neuroticism ( $r = 0.11$ ) and fearfulness was negatively related to extraversion in later years ( $r = -0.09$ ), while other associations were much weaker or statistically non-significant. The findings suggested that personality and temperament cannot be equated and rather have unique predictive validity: temperament was a stronger predictor of cognitive, educational, and occupational outcomes, whereas personality was more effective predicting family and social outcomes.

Finally, Hampson and Goldberg (2006) examined the consistency of individual differences from elementary-school into adulthood, in a sample of approximately 800 people who were assessed in elementary school between 1959 to 1967 and were assessed as adults approximately 40 years later. Characteristics similar to the B5 were assessed at childhood by teachers using two assessment formats whereas self-reported B5 personality in adulthood was assessed later on two occasions using conventional personality measures. Using canonical analysis, these authors observed correlations over time ranging from zero (neuroticism) to 0.29 (extraversion).

Altogether, even though this past research provides some leads, we note that the designs are still quite different from ours: several of these studies involved small samples; some measured temperament through parent- or caregiver-reports collected at a relatively older age than our study (e.g., Deal *et al.*, 2005; Hampson & Goldberg, 2006; Wright & Jackson, 2022), and in some studies the predictor and criterion were reported by the same source (Hagekull & Bohlin, 1998). Further, other researchers adopted either objective measures or expert-ratings as measurements of temperament rather than parent ratings (Caspi *et al.*, 2003; Caspi & Silva, 1995; Tang *et al.*, 2020). Finally, across the studies, there was considerable variance in the age at which temperament and personality were measured (e.g., Hagekull & Bohlin, 1998, 2003; Slobodskaya & Kozlova, 2016).

In addition to the various designs, we were also faced with considerable uncertainty around the basic factor-structure of temperament, and how that factor structure is affected by the age at which temperament is measured (Mervielde & De Pauw, 2012). Accordingly, while in the main investigation we adopt the nine-dimensional model proposed by Thomas and Chess, we also include supplemental analyses that adopt exploratory factor analytic methods. We also note the presence of sex differences in temperament (Else-Quest, Hyde, Goldsmith & Van Hulle, 2006) and HEXACO personality (Lee & Ashton, 2020), suggesting that sex is a potential confounder of the relations of temperament with personality. Accordingly, we examine associations between temperament and personality traits, both controlling for sex (i.e., examining whether there exists a common core driving temperament and personality beyond that which can be attributed to sex), and checking whether sex is a moderator.

## METHODS

This study was conducted with the approval of the Human Research Ethics Office of the University of Western Australia under the project title: Work Design Matters: The Dynamic Interplay of Work, Person and Context (RA/4/1/7871).

### Participants

The Raine Study, from where our participants were recruited, is a Western Australian based cohort study that commenced in 1989 (see Straker *et al.*, 2017, for details about the cohort). A total of 2,900 pregnant women, recruited around 18 weeks from gestation were invited to join the project, from a tertiary maternity hospital, King Edward Memorial Hospital, located in Perth, Australia. Data collection for the Raine Study continued after the live child births and is ongoing (<http://rainestudy.org.au>). The parent participants (Gen1, mainly mothers) provided sociodemographic information and observations of the growing children over the course of the study. Meanwhile, data regarding the child participants (Gen2) were collected via various means including direct observation, parental or teacher ratings, and, as the children grew older, self-ratings.

The current study involves 563 of the Gen2 participants who had volunteered to participate in our research project with the Raine Study on work and personality, which we conducted in 2016 and again in 2018 (at the approximate cohort ages of 26 and 28 years, correspondingly); any individual who participated in either project was included. A majority of these participants were female (61.5%). The supplemental materials provide some information about the effects of participant attrition and, in brief, the participants from our study appear to be somewhat higher on honesty-humility, slightly higher on agreeableness and conscientiousness, and lower on openness when compared to those of a similar age range, based in Australia (Ashton & Lee, 2016).

## MEASURES

### Sex

Children's sex was reported by their parents (dummy coded as *female* = 0 and *male* = 1).

### Infant temperament

Temperament was assessed by maternal report when the Gen2 participants were between 1 and 2 years of age using the Australian Revision of the Infant Temperament Scale (Carey & McDevitt, 1978; Oberklaid, Prior, Golvan, Clements & Williamson, 1984). This measure has been based on the Thomas and Chess model of temperament developed for longitudinal observational research. Within the larger cohort, profiles derived from this measure have been found to be associated with blood pressure (Robinson, Oddy, Whitehouse *et al.*, 2013), obesity (Van Lieshout, Schmidt, Robinson, Niccols & Boyle, 2013) and stress reactivity (Van Eekelen, Olsson, Ellis *et al.*, 2011), and other research has suggested the measure produces relatively stable scores over short periods of time (Fullard, McDevitt & Carey, 1984). The measure comprises 97-items that requires a primary caregiver to rate their child's behavior using a six-point scale ranging from *almost never* to *almost always*. There are nine dimensions that can be calculated from the items scores: activity level, rhythmicity, approach-withdrawal, adaptability, intensity, threshold of responsiveness, mood, distractibility, and persistence or attention span. The observed McDonald's omega reliability

estimates for these dimensions are presented in Table 1. Participants were also classified by the custodians of the cohort study using an algorithm based on the responses to the temperament measure into one of the following five temperament profiles: Difficult (12.6% of the sample), Easy (44.1%), Intermediate high (12.2%), Intermediate low (27.1%), or Slow to warm up (4.1%).

### HEXACO dimensions of personality

Participants completed the 96 items from the 100-item self-report of the HEXACO Personality Inventory-Revised (HEXACO PI-R) (Lee & Ashton, 2018). The instrument measures the six major dimensions of personality: honesty-humility, emotionality, extraversion, agreeableness, conscientiousness, and openness to experience, with 16 items per dimension.<sup>5</sup> Items are rated on a five-point scale ranging from 1 *strongly disagree* to 5 *strongly agree*. Sample items were as follows: honesty-humility (e.g., "I am an ordinary person who is no better than others"), emotionality ("I sometimes can't help worrying about little things"), extraversion ("I enjoy having lots of people around to talk with"), agreeableness ("I rarely hold a grudge, even against people who have badly wronged me"), conscientiousness ("I clean my office or home quite frequently"), and openness to experience ("I am interested in learning about history and politics of other countries"). For the supplemental analyses involving personality profiles, participants were classified into their most likely profile membership with latent profile analyses in Mplus using syntax provided by (Espinoza *et al.*, 2020) that provides starting values derived from their very large sample.

## ANALYTICAL STRATEGY

All analyses were undertaken using the *Mplus* 8.4 package (Muthén & Muthén, 1998–2017). To operationalize temperament through the nine dimensions, we undertook a confirmatory factor analysis (CFA) with maximum likelihood robust (MLR) estimation and exported the factor scores to use as predictors in the analyses that follow. Because of the inconsistencies regarding the empirical factor structure of many temperament measures and the unknown moderating role of target age (e.g., Martin *et al.*, 1994; Reynolds & Fletcher-Janzen, 2007), we also empirically derived a measurement model using exploratory analyses; these are reported in the supplemental document (see Tables S3–S6). As noted above, we also adopted a profile-based approach to operationalize temperament, with analyses involving the creation of dummy code variables to represent each of the five profiles. To model the HEXACO personality dimensions, we specified single indicator latent variables. The single indicators for each factor were the equally-weighted item composites (i.e., the mean of the responses to the 16 scale items), and the residual variance was fixed to be  $(1-\omega) \times \sigma^2$ , where  $\omega$  was the composite's reliability estimate and  $\sigma^2$  was the observed variance of the composite. This approach to modelling personality allows us to identify associations between the temperament factors and the personality factors absent any bias emerging from measurement error in either set of variables (Antonakis, Bendahan, Jacquart & Lalive, 2010).

Table 1. Intercorrelations among single indicator latent personality variables and confirmatory factor analysis-derived temperament factor scores

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
M (SD)																
1. Male																
2. Honesty-Humility	-0.22	0.82														
3. Emotionality	-0.53	0.07	0.83													
4. Extraversion	-0.01	-0.02	-0.10*	0.89												
5. Agreeableness	0.05	0.31**	-0.30**	0.24**	0.86											
6. Conscientiousness	0.05	0.14**	0.06	0.16**	-0.05	0.80										
7. Openness	0.12**	0.14**	-0.03	0.12*	0.14**	-0.07	0.85									
8. Approach/withdraw	0.02	-0.04	-0.10*	0.05	-0.04	0.02	0.01	0.86								
9. Quality of mood	0.01	0.01	-0.05	0.03	0.01	0.03	0.02	0.65**	0.68							
10. Intensity of reaction	0.03	-0.04	0.06	-0.01	-0.06	-0.04	0.02	-0.22**	-0.68**	0.63						
11. Rhythmicity	0.00 (0.50)	0.07	-0.03	0.05	0.02	0.02	0.04	0.22**	0.63**	-0.30**	0.67					
12. Persistence	0.00 (0.42)	-0.06	0.06	-0.02	0.00	-0.06	-0.04	0.14**	0.32**	-0.06	0.05	0.74				
13. Adaptability	0.00 (0.54)	-0.12**	0.00	-0.01	0.02	0.02	-0.01	0.44**	0.92**	-0.67**	0.56**	0.42**	0.62			
14. Activity Level	0.00 (0.48)	0.11**	-0.06	0.05	-0.04	0.02	0.03	-0.03	-0.60**	0.54**	-0.32**	-0.59**	-0.83**	0.61		
15. Distractibility	0.00 (0.04)	-0.04	0.00	-0.02	0.00	0.04	0.02	0.03	0.03	0.07	0.18**	-0.33**	.00	0.18**	0.56	
16. Threshold	0.00 (0.31)	-0.08	0.09	-0.04	-0.04	0.04	-0.05	-0.30**	-0.12**	0.24**	-0.02	0.22**	0.04	-0.02	0.22**	0.57

Notes: \* $p < 0.05$  \*\* $p < 0.01$   $n = 563$ . Figures along the diagonal are McDonald's omega coefficients. Variables 2-7 show descriptive statistics of the scale scores, not the single indicator latent variables. Variables 8-16 show descriptive statistics for the factor scores derived from a confirmatory factor analysis.

RESULTS

Confirmatory factor analysis (CFA)

First, we specified a classical CFA model whereby the 97 items would only load on their respective nine Thomas and Chess (1977) hypothesized factors (i.e., cross-loadings were fixed to zero). The fit indices provided mixed signals regarding the overall model fit ( $\chi^2 (4,523, N = 563) = 10810.181, p < 0.05$ ; root mean squared error of approximation (RMSEA) = 0.050 (90% confidence interval: .048, .051); comparative fit index (CFI) = 0.504; Tucker-Lewis index (TLI) = 0.490; standardized root mean squared residual (SRMR) = 0.08, see Table S3 in supplement). Based on previous evidence (Comrey & Lee, 2013), we interpreted any factor loadings of below 0.32 (i.e., items that shared less than 10% of the variance with a factor) as “weak” and according to this criterion, 33 of the 97 items (34%) exhibited weak factor loadings. Accordingly, in the online supplement, we present several alternative approaches, but we retained this model for the main analyses.

Statistical prediction of personality traits

First, we inspected the zero-order associations of the nine temperament factors with the six HEXACO personality factors (see Table 1). We found that, in adulthood, the women participants tended to be higher on emotionality, honesty-humility, conscientiousness, and lower on openness to experience than the males ( $d = -1.42, d = -0.49, d = -0.28,$  and  $d = 0.24,$  respectively), which aligns with earlier evidence (e.g., Lee & Ashton, 2020). Sex differences in temperament were relatively small with boys exhibiting slightly more difficulty to retain focus than girls.

The temperament dimensions showed some many associations with one another (see Table 1). For example, the quality of mood dimension was strongly ( $|r| \geq 0.60$ ) associated with approach/withdraw, intensity of reaction, rhythmicity, activity level, and was nearly perfectly negatively correlated with adaptability, which itself showed strong associations with activity level and intensity of reaction. The zero-order associations among the personality traits were relatively small, with the largest involving agreeableness with honesty-humility and emotionality. Associations of personality with the temperament scores were very close to zero with none reaching statistical significance.

To examine the joint associations of the temperament and personality, and to control for sex, we conducted SEM in three steps. In step 1, we regressed each of the six single-item latent HEXACO variables onto sex, then in step 2, we added the nine temperament factor scores as predictors. In Step 3, we added a sex  $\times$  [temperament factor score] product interaction term to investigate whether the associations of temperament and adult personality were moderated by sex. We repeated step 3 eight times, once for each temperament factor score. We report the results of step 2 in Table 2, and with reference to step 1 below, and all remaining results in the online supplement (see Table S7).

The regression analyses suggested that, after controlling for sex and the remaining dimensions, no single temperament dimension was significantly associated with the emotionality, extraversion,

Table 2. Regression of single indicator latent personality variables onto the nine temperament dimensions

Predictors	Honesty-Humility		Emotionality		Extraversion		Agreeableness		Conscientiousness		Openness	
	<i>b</i>	95% CI	<i>b</i>	95% CI	<i>b</i>	95% CI	<i>b</i>	95% CI	<i>b</i>	95% CI	<i>b</i>	95% CI
Male	-0.214*	-0.31, -0.12	-0.584*	-0.67, -0.50	-0.038	-0.15, 0.07	0.058	-0.04, 0.16	-0.129*	-0.21, -0.04	0.149*	0.04, 0.25
Approach/withdraw	0.172	-0.09, 0.43	-0.09	-0.34, 0.16	-0.089	-0.40, 0.22	-0.144	-0.43, 0.14	0.047	-0.19, 0.28	0.166	-0.13, 0.46
Quality of mood	0.199	-0.32, 0.72	-0.259	-0.76, 0.24	-0.103	-0.72, 0.52	-0.292	-0.86, 0.28	-0.174	-0.65, 0.30	0.253	-0.34, 0.85
Intensity of reaction	-0.183	-0.43, 0.06	0.092	-0.14, 0.33	-0.043	-0.33, 0.25	-0.089	-0.35, 0.18	-0.142	-0.36, 0.08	-0.312*	-0.59, -0.03
Rhythmicity	0.181*	0.01, 0.35	-0.038	-0.20, 0.12	0.055	-0.14, 0.25	0.000	-0.18, 0.18	0.037	-0.11, 0.19	0.151	-0.04, 0.34
Persistence	-0.259	-0.58, 0.06	0.121	-0.18, 0.42	0.161	-0.22, 0.54	0.188	-0.16, 0.53	-0.032	-0.32, 0.25	-0.133	-0.49, 0.23
Adaptability	-0.876	-2.13, 0.38	0.502	-0.70, 1.70	0.431	-1.06, 1.92	0.679	-0.69, 2.04	0.206	-0.93, 1.34	-0.974	-2.40, 0.45
Activity level	-0.599	-1.51, 0.31	0.271	-0.60, 1.14	0.515	-0.57, 1.60	0.463	-0.53, 1.45	0.145	-0.68, 0.97	-0.575	-1.61, 0.46
Distractibility	-0.969	-2.04, 0.11	-0.092	-1.12, 0.93	-0.484	-1.76, 0.79	0.339	-0.83, 1.51	-0.134	-1.10, 0.83	0.294	-0.93, 1.52
Threshold	0.367	-0.08, 0.81	-0.133	-0.56, 0.29	-0.202	-0.73, 0.33	-0.306	-0.79, 0.18	0.074	-0.33, 0.48	0.265	-0.24, 0.77
R <sup>2</sup> (male only)	0.046		0.281		0.000		0.002		0.019		0.014	
R <sup>2</sup> (male + temperament)	0.064		0.296		0.016		0.014		0.033		0.037	
ΔR <sup>2</sup>	0.018		0.015		0.016		0.012		0.014		0.023	

Notes: \**p* < 0.05. *N* = 563. *b* = unstandardized regression coefficient, CI = confidence interval.

agreeableness, or conscientiousness dimensions. Honesty-humility was significantly associated with rhythmicity (*b* = 0.181, *p* = 0.034), and Openness was negatively associated with intensity of reactions (*b* = -0.312, *p* = 0.028). Given the volume of statistical tests and the non-significant zero order associations, we advise caution in interpreting these two results. Indeed, the incremental variance explained by temperament over sex was very small, ranging from 1.2% to 2.3%.

In step 3, we investigated whether sex moderated the relations of temperament dimensions with adult HEXACO traits. Full regression models are reported in the online supplement. We found several statistically significant interaction effects. First, we found that for males, approach/withdraw was a negative predictor of emotionality, conditional on the remaining temperament dimensions, the association was close to zero (*b* = 0.215 for men; *b* = -0.017 for women; *p* for interaction term = 0.003). We also found that for males, the negative association of distractibility and honesty-humility, conditional on the remaining temperament dimensions, was stronger than for women (*b* = -2.271 vs. -0.283, *p* for interaction term = 0.045). No additional interaction effects reached statistical significance.

Finally, we investigated whether there were differences in trait levels across the temperament profiles through a set of six analyses that involved regressing the six single-indicator latent HEXACO variables onto four dummy variables representing four of the five temperament profiles, with the fifth profile being the reference profile. We also controlled for participants' sex. The results are presented in Table 3, and they show that the temperament profiles were not significantly associated with any of the HEXACO traits. Reparameterization of the model with alternative profiles as the reference category revealed a single statistically significant effect (*p* = 0.012); namely, being in the "intermediate - low temperament" profile was positively associated with emotionality, relative to being in the "easy" category.

DISCUSSION

The purpose of the current study was to examine whether adult personality is associated with temperament, a question that stems from the trait continuity hypothesis, according to which the core in individual differences can be traced throughout life (Bornstein, 2014; Bornstein *et al.*, 2019). Our study contributed to the literature examining this hypothesis through a: (1) lagged design; (2) large sample size; (3) measurement of temperament, rated by parents, at a very early age (1-2 years); and (4) self-reported measurement of personality during the late 20s. Moreover, our study included a multi-dimensional temperament assessment (cf. Tang *et al.*, 2020) and is the first to our knowledge to examine relations of temperament with the HEXACO personality model. Finally, in combination with our supplemental analysis, we also examined both temperament and personality using profile and dimensional approaches to operationalizing each.

We found that a measurement model of the nine-dimensional factor structure (Thomas & Chess, 1977, 1984) was not well-fitting, with several items exhibiting very low factor loadings and with several factors being very strongly associated with others.



Table 3. Regression of single-indicator HEXACO personality scores onto sex and the temperament profiles

Predictors	Honesty-Humility		Emotionality		Extraversion		Agreeableness		Conscientiousness		Openness	
	<i>b</i>	95% CI	<i>b</i>	95% CI	<i>b</i>	95% CI	<i>b</i>	95% CI	<i>b</i>	95% CI	<i>b</i>	95% CI
Male	-0.210**	-0.30, -0.12	-0.591**	-0.68, -0.50	-0.024	-0.13, 0.09	0.067	-0.03, 0.17	-0.117**	-0.20, -0.03	0.15**	0.05, 0.25
Easy	0.076	-0.07, 0.22	-0.134	-0.27, 0.00	-0.016	-0.18, 0.15	0.085	-0.07, 0.24	0.041	-0.09, 0.17	0.11	-0.05, 0.27
Intermediate High	0.112	-0.07, 0.29	-0.098	-0.27, 0.07	-0.095	-0.31, 0.12	0.111	-0.08, 0.31	0.025	-0.14, 0.19	0.156	-0.05, 0.36
Intermediate Low	0.113	-0.04, 0.26	-0.002	-0.15, 0.14	-0.035	-0.22, 0.15	0.040	-0.12, 0.20	-0.049	-0.18, 0.09	0.125	-0.05, 0.30
Slow to Warm Up	0.193	-0.06, 0.45	-0.100	-0.34, 0.14	0.117	-0.18, 0.42	0.059	-0.22, 0.33	0.161	-0.07, 0.39	-0.104	-0.39, 0.18
<i>R</i> <sup>2</sup> (male only)	0.046		0.281		0.000		0.002		0.019		0.014	
<i>R</i> <sup>2</sup> (male + temperament)	0.049		0.291		0.005		0.007		0.031		0.026	
$\Delta R^2$	0.003		0.010		0.005		0.005		0.012		0.012	

Notes: \**p* < 0.05, \*\**p* < 0.01, *N* = 565. *b* = unstandardized regression coefficient, CI = confidence interval. Difficult temperament was the reference category.

This result reflects those of other studies conducted in early childhood and infancy (Thomas & Chess, 1977, 1984) that have suggested that the factor structure of this model is unclear. A supplemental analysis using exploratory factor analytic methods provided a better-fitting alternative, however, the fit in absolute terms was still poor. Nonetheless, we also must acknowledge that multidimensional personality measures such as the HEXACO Personality Inventory also often fail to yield clear, consistent, well-fitting measurement models (Hopwood & Donnellan, 2010), and are themselves derived from exploratory analyses employed in lexical studies.

Altogether, we observed only very weak associations of temperament at ages 1–2 with personality measured in the late 20s, and this remained true whether we controlled for sex (which yielded two statistically significant effects out of 54), examined sex as a moderator (which identified two associations that were stronger among males than females, out of a possible 54 moderating effects), or operationalized temperament through a profile-based approach. Further in a supplemental analysis involving personality profiles, we also failed to find any clear associations between personality and temperament.

Thus, overall, at the surface, our findings would appear to contradict the trait continuity hypothesis, suggesting that learning systems are more likely to be responsible for the development of adult personality. We must, however, recognize that the context of this research provides an especially “strong” test of this hypothesis. For example, temperament was measured via parental reports and at a relatively young age. Although parents are perhaps in the best position to witness the totality of a child’s behavior and responses, they may lack the clear frames of reference that are presumably available to alternative raters such as experts in child development. Further, as children go through major changes in early age, it is likely that temperament is itself somewhat unstable in the age range we examined.

### ASSOCIATIONS OF TEMPERAMENT DIMENSIONS WITH PERSONALITY DIMENSIONS

#### Emotionality

The emotionality trait describes the tendency to experience vulnerability, sentimentality, and fearfulness versus fearlessness, detachment, and toughness. Though literature suggested there are connections between emotionality and temperament, both CFA-based and an alternative trait-models revealed a significant negative association with the approach-withdrawal temperament dimension. The CFA-based model showed no significant predictors of emotionality, while approach/withdraw dimension indeed significantly (negatively) predicted emotionality but only for males. The latter was also found for the eight-factor model. Wright and Jackson (2022) presented evidence of a positive, albeit weak, association between fearfulness and emotional instability (*r* = 0.06). Further, we also found that infant boys who are higher on approach (compared to girls) scored relatively lower on emotionality in adulthood, an association that also aligns with existing longitudinal research (e.g., Caspi *et al.*, 2003; well-adjusted, *z* = -0.06; Deal *et al.*, 2005; *b* = -0.25).

### Extraversion

Extraversion describes the tendency to intensively and actively express positive emotions, and to seek and positively respond to opportunities of social engagement. Interestingly, we found extraversion to be least connected to the infant behavioral responses, based on both the CFA and alternative explorative approaches to operationalizing temperament dimensions. This result is sharply in contrast with earlier research which suggests that extraversion has a stronger genetic basis among the major dimensions, and the empirical relations observed in other lagged designs (e.g., Caspi, Roberts & Shiner, 2005; De Pauw & Mervielde, 2010; Kandler *et al.*, 2012; Mervielde, De Clercq, De Fruyt & Van Leeuwen, 2005; Tang *et al.*, 2020). In the eight-factor model, we found one interaction involving sex where boys that were higher on persistence became more extraverted adults than those who were lower. The direction of this association contradicts existing longitudinal literature, however, which has instead suggested extraversion is associated positively with impulsivity (i.e., the expected inverse of persistence; e.g., Caspi *et al.*, 2003;  $z = 0.13$ ; Deal *et al.*, 2005;  $B = 0.27$ ).

### Conscientiousness

Conscientiousness reflects a tendency to engage in task-related endeavors demonstrating diligence, organization, and responsibility to obligations. According to earlier evidence, conscientiousness was the least predicable from temperament dimensions (e.g., Hagekull & Bohlin, 1998, 2003), which aligns with our CFA-based findings; however, our supplemental findings from the exploratory eight-factor model showed that adults' conscientiousness was negatively associated with rhythmicity and positively associated with activity level in infancy. In contrast, other studies have observed positive associations of conscientiousness with children's self-regulation (De Pauw *et al.*, 2009; Evans & Rothbart, 2007; Slobodskaya & Kozlova, 2016).<sup>6</sup> We speculate here that the unexpected direction of the associations observed in this study may relate to how these two temperament dimensions manifest, specifically, at ages one to two. Specifically, around the age of one, children start walking, a newly acquired skill that requires higher self-regulation (or motor control; Fox & Riconscente, 2008). Therefore, a positive association between conscientiousness and an *infant's* (as opposed to toddler) activity may be developmentally grounded. Moreover, the ability to be active through walking and running can indicate children's ability to focus attention and control the self, which was found to be predictive of self-regulation later in life (e.g., Kochanska, Murray & Harlan, 2000). Similarly, rhythmicity at the early age may not reflect the same meaning when compared to older children, because habits and routines of infants are less conscientious and less subjected to a child's control (e.g., Gillespie & Seibel, 2006). Though there was some longitudinal evidence to link conscientiousness to rhythmicity, Guerin *et al.* (2003) found that rhythmicity (habits) was positively associated with conscientiousness at age 17 ( $r = 0.23$ ), the design of the study, in particular repeatedly measured from multiple measurements from infancy to middle childhood and averaged value, is not comparable to our single measure in infancy.

### Agreeableness

Agreeableness, in the HEXACO model, denotes a tendency to be cooperative, patient, and lenient. Conceptually there is a clear correspondence of adult agreeableness and cooperativeness in infancy, and our study provides support for this relation. We also note earlier longitudinal research (Hagekull & Bohlin, 2003; Wright & Jackson, 2022), which identified relations of sociability with B5 agreeableness. In contrast with other studies, however, we did not observe relations with agreeableness and approach (cf. Guerin *et al.*, 2003;  $r = 0.24$ ) although we did observe a negative association of agreeableness with persistence among the female participants in the eight-factor model, while no significant associations were found in CFA-based model. Therefore, our findings contribute to the existing literature and theoretical connection where a tendency of a child to exhibit prosocial, cooperative behaviors to please others and required self-regulation found to be related to this trait (De Pauw *et al.*, 2009; Graziano, Habashi, Sheese & Tobin, 2007; Shiner & DeYoung, 2013).

### Openness to experience

Openness describes the tendency towards curiosity, creativity, and a preference for novelty against the choice of convention and predictable patterns. Though this trait appears to have relatively weaker genetic components than other major personality dimensions (e.g., Caspi *et al.*, 2005; De Pauw & Mervielde, 2010; Mervielde *et al.*, 2005), based on the eight-factor exploratory measurement model of temperament, we found that infants with lower regulatory incapacity (i.e., higher ability to self-regulate) were more open to experience as adults. This finding is consistent with earlier longitudinal research which suggest that openness is positively associated with self-regulation (e.g., Caspi *et al.*, 2003; well-adjusted,  $z = 0.13$ , vs. under-controlled,  $z = -0.34$ ). Moreover, Shiner and DeYoung (2013) linked this trait to a tendency to be less rigid and quicker to learn/adjust behavior, a quality that in young children can be observed on the base of higher responsiveness to the subtle changes in the surroundings. Our regulatory (in)capacity dimension, in turn, reflects similar tendencies. Therefore, our finding contributes to theoretical and empirical connections between infant's self-regulation and openness to experience. In addition, the CFA-based model showed that childhood intensity of responses was a significant negative predictor of openness in adults, which corresponds with earlier evidence of self-regulation.

### Honesty-humility

Honesty-humility refers to a tendency to engage in altruistic, selfless, prosocial behavior, following the rules, feeling no special than others. There is an absence of evidence on the predisposed foundation of honesty-humility, presumably due to its short history in the study of personality, as well as a shortage of longitudinal research examining this trait. The present study offers evidence of a weak but positive association between infant cooperativeness and honesty-humility among males based on the eight-factor exploratory measurement model of temperament and a significant negative association with rhythmicity based on the

CFA-based model. We note that Caspi *et al.* (2003) found that children with *under-controlled type* of behavioral style characterized by impulsivity, restlessness, negative responses, distractibility and low emotional regulation at the age 3 showed tendencies to antisocial behaviors (which are negatively associated with honesty-humility; Zettler *et al.*, 2020) at 26. Our finding, therefore, provides empirical support to the theoretical link between cooperativeness, a dimension that often incorporates child's self-control by acting to please others which often delays gratification (i.e., against personal interests that refers immediate gratification) and the trait that features suppression of one's selfish instincts, both of which reflect a similar core in the type of self-regulation. Moreover, earlier research demonstrated that high-empathy children revealed enhanced abilities to regulate themselves (Miller & Jansen op de Haar, 1997), which is also consistent with our finding. The finding provides support to theoretical connection between honesty-humility and early prosocial tendencies measured through cooperativeness (i.e., affiliation), based on Ashton and Lee's (2007) trait conceptualization.

#### ASSOCIATIONS OF TEMPERAMENT AND PERSONALITY PROFILES

Research into genetic associations with temperament with personality has suggested that larger associations are observed when person-centered approaches are adopted. Our attempts at person-centered analyses, however, did not identify any clear associations of temperament profiles with personality dimensions, temperament profiles with personality profiles, nor temperament dimensions with personality profiles. While it is possible that the profile derivation methods for both measures are not grounded in the same mechanisms that give rise to associations attributable to genetic factors, we do note that researchers who have used latent profile analyses to derive profiles have found relatively strong genetic associations.

#### LIMITATIONS

Altogether, the strength of the associations of temperament and personality were weak. While these results might seem to contradict the trait continuity hypothesis, there are important considerations and potential limitations that must be brought to light. First, while generally exceeding cross-sectional studies in terms of methodological rigor, longitudinal studies are at risk of attrition, that can introduce bias. For example, participants who have certain temperament or personality characteristics may be more predisposed to participate in our study or to withdraw from the cohort study altogether. Of note, in the data we accessed, the sample was proportionately over-represented by women from the cohort and appeared to be higher on some traits than other Australian samples of similar ages (see supplement for details).

Second, we speculate that the absence of many associations between temperament and personality may be due to the reliance on parental reports of temperament, which while commonplace, are at risk of being biased. For example, psychological factors such as parental depression and parents' own personalities can affect temperament reports of their children (e.g., Clark, Durbin, Donnellan & Neppel, 2017). Further, parents (especially first-time

parents) may lack a meaningful point of reference for judging the frequencies their infant child's behaviors. Unfortunately, in the present study, there were no temperament ratings from neutral others, nor were there objective behavioral measures, and thus we cannot rule out the possibility that the parental reports were contaminated by other factors, reflecting not only their children's temperaments. While laboratory observed infant temperament at 6–12 months was modestly associated with parental report of the temperament (Planalp, Van Hulle, Gagne & Goldsmith, 2017), found that both parental and direct assessment toddlers' skills (motor and language) were also found to be reliable measures. Indeed, there is evidence that indicates that observers' reports overlap with maternal reports, providing support for an objective component in the maternal ratings of temperament (Bates & Bayles, 1984), and indicating that subjective biases do not overshadow the objective temperament component in parental reports (Bates & Bayles, 1984).

Similarly, the model of temperament used in this investigation did not provide strong fit with the data generated by the measures, even with more liberal exploratory approaches. Accordingly, stronger associations may have been observed had an alternative model of temperament been adopted. Finally, we also must urge caution with respect to interpreting the statistically significant effects that were observed. Overall, there were a very large number of tests undertaken, each of which generates an opportunity for a Type 1 error to emerge.

#### CONCLUSIONS

Overall, we were surprised by the paucity of published longitudinal studies of temperament in early childhood and adult personality, given the theoretical appeal and prominence of the trait continuity hypothesis. While our literature search also identified at least two other large longitudinal cohort studies where temperament in childhood and personality in adulthood were measured (Australian Temperament Project and the Longitudinal Study of Australian Children), we were not able to locate publications empirically connecting the two variable sets. Recently, Wright and Jackson (2022) presented results from the National Longitudinal Study of Youth 1979, revealing little overlap between the temperament and young adult personality, in line with our findings. One potential explanation for this is a parent ratings effect, that could contribute to the measurements of child's temperament, independently of the "true" temperament. We speculate that the challenges of collecting non-parental ratings of temperament, potentially less contaminated than parental ratings, has meant that observed relations of temperament with personality are likely weak in other data sets. We therefore encourage future researchers to adopt objective or expert measures of temperament where stronger associations with personality have been observed (e.g., Caspi *et al.*, 2003; Tang *et al.*, 2020). Alternatively, these findings also suggest that there is imperfect trait continuity in long-term longitudinal data due to maturation of the traits (e.g., Denissen *et al.*, 2013), where the age of temperament measurement is of utmost importance (Kopala-Sibley *et al.*, 2018), and inequality of the concepts representing heterotypic continuity of the traits (Wright & Jackson, 2022).

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The data that support the findings of this study are available from The Raine Study ([www.rainestudy.org.au](http://www.rainestudy.org.au)). Restrictions apply to the availability of these data, which were used with permission from the Raine Study for this research.

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#### ENDNOTES

<sup>1</sup> Rothbart's Effortful Control, Buss and Plomin's Sociability/Shyness and Thomas and Chess' Threshold/Distractibility are unique in each of their respective models. For example, Effortful Control (or Regulation Capacity in infants/toddlers; self-regulation "capacity to inhibit a dominant response in order to perform a subdominant response"; Rothbart, 2019, p. 3) describes the ability to control "innate tendencies" of one's affective, physical, or attentional reactivity ("the capacity"). Rothbart and Bates (2006) introduced an Affiliation dimension, emotional closeness, warmth to others and pleasure from social interaction, which is thought to be linked to the ability to experience complex emotions like empathy and concern for others (Evans & Rothbart, 2007).

<sup>2</sup> While acknowledging that differences between the models exist, for this review, we consider them equivalent.

<sup>3</sup> Guerin *et al.* (2003), in a longitudinal study, systematically measured temperament from one year through 17, where up to five years measurements represented parent-report submitted every six months and after yearly, using the Thomas and Chess framework, and recovered a temperament dimension they labeled *task orientation*.

<sup>4</sup> Caspi *et al.* (2003), Caspi and Silva, (1995) involved categorizing children into five groups. *Well-adjusted* children expressed capability of self-control, some confidence and adequate tolerance of novelty without getting upset in such an encounter. *Confident* type included children were adaptive to new situations, friendly and impulsive, not afraid to be without the parent/caregiver. *Under-controlled* children expressed impulsivity, restlessness, negativity, distractibility, and emotional instability. Finally, the *reserved* type included children who were timid, uncomfortable under examination, slightly inhibited but not to the degree to prevent their task performance, whereas *inhibited* children were very shy, fearful, and easily upset.

<sup>5</sup> The four omitted items form an interstitial facet scale, altruism, which was not relevant to the larger research project.

<sup>6</sup> Self-regulation allows for the control of inappropriate behavior and emotional responses such as suppressing fearful impulses when exposed to

a novel stimulus (Rothbart & Bates, 2006). While attentional control operationalized through an ability to concentrate attention on stimuli (Rothbart, Chew, & Gerstein, 2001), and sustain it (Martin *et al.*, 1994), in infants and toddlers, respectively.

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- Table S1.** Thomas and Chess' Model of Temperament: Dimensions, Their Content and Correspondence to Rothbart, Bass & Plomin, and Goldsmith Temperament Models
- Table S2.** Obstacles Preventing Synthesis of Research on Relationships between Temperament and Personality Traits
- Table S3.** Goodness of Fit Statistics for the Estimated Models on Infant Temperament Questionnaire\*
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- Table S8.** Prevalence of HEXACO Profiles Observed in this Investigation compared to Espinoza et al.
- Table S9.** Contingency Table of HEXACO by Temperament Profiles
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- Figure S1.** Parallel Analysis Plot
- Figure S2.** Means deviations of HEXACO scores, by sex, by sample. Error bars are 95% confidence intervals. A&L = Ashton & Lee. CI = Current Investigation. Note the y-axis has been rescaled from 1-5 to allow study group differences to show clearly

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article: