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# Aggregate temperament scores from multiple countries: Associations with aggregate personality traits, cultural dimensions, and allelic frequency

Samuel P. Putnam [a,*], Maria A. Gartstein [b]

[a] Department of Psychology, Bowdoin College, United States
[b] Department of Psychology, Washington State University, United States

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ABSTRACT

Aggregate temperament scores were calculated across 17 studies for 18 countries. These scores were analyzed in relation to aggregate personality scores, cultural orientation, and allelic distribution reported in prior studies. Cross-culture patterns were largely consistent with those previously reported for personality: countries high on Surgency (SUR) were high on Extraversion, high Negative Affectivity (NEG) was consistent with Neuroticism, and Regulatory Capacity (RC) with Agreeableness. Regarding cultural orientation, aggregate SUR was associated with low Power Distance and Long-Term Orientation; NEG with low Individualism and high Masculinity and Uncertainty Avoidance; and RC with low Power Distance and Masculinity. Higher proportion of MAOA-uVNTR low expression alleles was associated with low SUR and low RC; and A118G G-form allele proportion with low RC.



## 1. Introduction

Those who travel the world are frequently struck by the differences that exist in the ways people from different parts of the world conduct themselves. Acknowledgement of such differences has been apparent for millennia: as early as the fifth century, the Greek philosopher Thucydides contrasted the self-control and stoicism characteristic of Spartans with the more indulgent and free-thinking citizens of Athens (Lee & Morley, 2015). To this day, such observations typically concern themselves with adult behavior, scarcely paying attention to dissimilarities that might exist between the youngest members of societies. Temperament, defined as early appearing and relatively stable individual differences in reactivity and self-regulation, is a useful construct for exploring such differences in infants and children. In this paper, we summarize temperament data collected in countries around the globe, and relate these to indicators obtained for adult personality dimensions, the values that characterize different cultures, and biological underpinnings that shape and are shaped by cultures.

The inescapable power of culture is largely a function of the fact that it provides a constant background of philosophy, shared history, and geo-political factors, which jointly impact the environment of the developing individual at essentially every moment of life. Culture, then, provides a unique lens for examining the origins of individual differences in reactivity and regulation. In essence, cross-cultural studies represent "natural experiments", wherein culturally influenced family/parenting variables are not being manipulated, yet change systematically as a function of cultural exposures, powerful with respect to shaping individual differences. Although it must be acknowledged that the variability within cultures is typically greater than differences between them, we have observed considerable cultural contributions in our own work addressing temperament (e.g., Gaias et al., 2012; Slobodskaya, Gartstein, Nakagawa, & Putnam, 2013), and others have noted that effect sizes associated with culture are often greater than those for age and gender, also significant factors in shaping social-emotional development (Achenbach & Rescorla, 2007; McCrae et al., 2010).

Although theory and research addressing cross-cultural variability in individual differences has framed the pathway of influence from culture to temperament/personality, the reverse effects are also possible, and have been discussed in the context of processes related to "culture-gene coevolution". According to the culture–gene coevolutionary theory, cultural values have

* Corresponding author at: Department of Psychology, Bowdoin College, Brunswick, ME 04011, United States.
*E-mail address:* sputnam@bowdoin.edu (S.P. Putnam).

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evolved, and influence the environment (social and physical) under which genetic selection takes place (Boyd & Richerson, 1985). With respect to processes relevant to temperament, characteristics of those from different cultural groups, driven in part by genetic influences, may shape expected/acceptable ways of behaving in social matters, such as expression of emotions, and prioritization of rewards and threats in the formation of societal concerns (Chiao & Blizinsky, 2010; Jack, Garrod, Yu, Caldara, & Schyns, 2012; Matsumoto et al., 2008; Way & Lieberman, 2010). In turn, natural selection likely works to enhance the survival and reproductive fitness of those possessing genes linked to behavior patterns that yield success in a given social and physical environment.

### 1.1. Goals of the current study

Despite the promise of cross-cultural research to inform our understanding of individual differences, the majority of studies examining differences in temperament have focused on only two to four cultures (e.g., the U.S. and Netherlands, Sung, Beijers, Gartstein, de Weerth, & Putnam, 2015), single dimensions (e.g., shyness, Chen et al., 1998), or constructs that may not apply similarly across different ages (e.g., difficulty, Super et al., 2008). In contrast, personality research has captured a more extensive body of cultures around the world (e.g., McCrae, 2001), but these studies have focused primarily on adults and adolescents. In response to these shortcomings, the initial goal of the current study was to consolidate temperament data across multiple investigations in order to discern patterns of cross-cultural variability for three factors identified as important across the lifespan.

Next, we set out to assess similarities and dissimilarities in the correspondence between culture and individual differences in terms of domains that have emerged from the study of adult personality and temperament development. Because the 5-factor model of personality traits bears some similarity to attributes emerging in studies of temperament structure (e.g., Rothbart, Ahadi, & Evans, 2000), important information could be revealed by jointly considering these two sets of individual difference domains across cultures. Findings of similar patterns would support the inference of commonality of constructs assessed in these two traditions, and suggest that the patterns observed in adult personality have roots in processes observed in infancy and childhood. Dissimilarities would promote a more nuanced understanding of the comparability of constructs, providing information regarding the implications of culture for individual differences at differing points in the life course.

A third goal was to explore aspects of cultural orientation as correlates of temperament characteristics. Prior studies have emphasized collectivism and individualism, and there are other important distinctions between cultures that govern aspects of personal interaction and socialization goals, ultimately helping to shape the individuals living within these systems. This goal is addressed through an analysis of relations between aggregate temperament scores and ratings on six cultural dimensions comprising a widely validated model of cultural orientation. Prior studies have examined four of these dimensions in relation to personality, providing a basis for expectations regarding their links to temperament. Two newer dimensions have not yet been studied in relation to individual-level variables, providing an opportunity to address novel questions regarding societal values and patterns of reactivity and regulation.

A final goal was to explore potential genetic contributions to cultural differences in temperament. Despite notable contradictory findings and failures to replicate, molecular geneticists have made substantial progress over the past 15 years in understanding the relationships between individual genes and psychological functioning. Until recently, these studies have been conducted primarily in the context of exploring differences within a population. Recent investigations, however, provide a model for studying between-culture variability. These studies (e.g., Chiao & Blizinsky, 2010; Minkov, Blagoev, & Bond, 2015; Way & Lieberman, 2010) have reported on correspondence between the prevalence of certain alleles in specific geographic regions along with information concerning aspects of cultural orientation and rates of psychopathology in these areas. We extend this thread of investigation, determining whether these patterns of allelic distribution correspond to the aggregate temperament traits characterizing the different regions involved.

### 1.2. Temperament and personality

Temperament can be thought of as the "core" of personality, shaping the development of additional facets that come online later in childhood (Rothbart, 2011). Although personality is a more inclusive category, temperament constructs overlap both conceptually and empirically with personality (De Pauw, Mervielde, & Van Leeuwen, 2009; Rothbart et al., 2000; Shiner & DeYoung, 2013). Rothbart (2011) has suggested that temperament traits represent a subset of personality dimensions that can be measured in the first few years, with some traits apparent at birth, and possibly prenatally (e.g., DiPietro, Hodgson, Costigan, & Johnson, 1996), as well as observed in non-human species (e.g., Panksepp & Burgdorf, 2003).

The psychobiological model of temperament proposed by Rothbart and Derryberry (1981) defined temperament as constitutionally based individual differences in emotional, motor, and attentional reactivity, and in self-regulation, that demonstrate consistency across situations and relative stability over time. The term 'constitutional' stresses the connection between temperament and biology, including the underlying physiological, neurobehavioral, genetic and epigenetic influences. Emotional reactivity applies to fear, anger, sadness, and positive emotions, whereas self-regulation refers to processes serving to modulate reactivity, supported by attention functions, including orienting attention during infancy and executive attention later in childhood and adulthood. The psychobiological approach attempts to identify unique domains of temperament (a number of which correspond to attributes noted in other temperament frameworks), mapping these onto underlying neurobehavioral systems, and outlining their developmental pathways and interactions, and can be applied to temperament observed across the lifespan.

Structurally, the psychobiological model encompasses three overarching factors comprised of fine-grained attributes. Although specific components measured at different ages are far from identical, higher order temperament constructs extracted from parent- and self-report measures across different developmental periods are remarkably similar (Gartstein & Rothbart, 2003; Putnam, Ellis, & Rothbart, 2001; Putnam, Gartstein, & Rothbart, 2006; Rothbart, Ahadi, Hershey, & Fisher, 2001). The first of these, Negative Emotionality (NEG), involves tendencies to experience and display fear, anger, sadness and physical discomfort. Surgency (SUR) emerges as a second factor, primarily manifested through smiling, laughing, activity, appreciation of high intensity stimulation and approaching novel stimuli. A third factor, referred to as Regulatory Capacity in infancy and later as Effortful Control (RC), includes attentional abilities, behavioral control, and enjoyment of calm activities.

Investigations of personality structure have generated support for a similar three-factor model (Aziz & Jackson, 2001; Eysenck & Eysenck, 1975; Tellegen, 1985); however, most contemporary research is characterized by models with a five-factor structure (Costa & McCrae, 1992; Digman, 1990; Goldberg, 1993). Considerable consensus among personality researchers has emerged

regarding this five-factor structure, and the meaning of the five factors, often labeled as: Neuroticism (N), Extraversion (E), Conscientiousness (C), Agreeableness (A), and Openness to Experience (O). Instruments assessing these constructs have been utilized in a variety of research contexts, including cross-cultural applications with both adolescents and adults (De Fruyt, De Bolle, McCrae, Terracciano, & Costa, 2009; McCrae, 2001, 2002; McCrae, Terracciano et al., 2005a).

Temperament factors that represent the psychobiological framework bear considerable similarity to those derived via the five-factor model of personality. N, which is composed of subcomponents including Anxiety, Hostility and Depression, is conceptually consistent with NEG. E, a construct involving sociability, activity and positive affect, is analogous to SUR. With enjoyment of novel activities and stimuli as a component, SUR also bears similarity to O. The demonstration of attentional and behavioral control that characterizes RC appears to represent an early manifestation of C. A does not have an apparent counterpart in the psychobiological temperament structure. However, three-factor models of personality have revealed a Psychoticism factor that appears to be a combination of A and C (Costa & McCrae, 1992; Eysenck & Eysenck, 1975; Scholte & De Bruyn, 2004), suggesting that the regulatory temperament factor may be related to A as well. Empirical analyses of adult temperament and personality confirm the similarity of constructs arising from these separate traditions. For example, Rothbart et al. (2000) reported correlations ranging from 0.43 to 0.59 for Adult Temperament Questionnaire factors and their Big Five counterparts.

### 1.3. Cross-cultural studies of individual differences

Cross-cultural differences in temperament and personality have been identified, starting with infancy and into adulthood. Cross-cultural temperament research with infants and toddlers has not been as common as personality studies, which demonstrated the robustness of the five-factor model from childhood to adulthood across languages, cultures and political systems (De Fruyt et al., 2009; Kohnstamm, Halverson, Mervielde, & Havill, 1998; McCrae et al., 2005a). However, it should be noted that the three-factor framework consistent with the psychobiological approach (i.e., SUR, NEG and RC) has been supported by cross-cultural investigations (Gartstein, Knyazev, & Slobodskaya, 2005; Montirosso, Cozzi, Putnam, Gartstein, & Borgatti, 2011).

Cross-cultural temperament research with children has revealed a number of mean-level differences in fine-grained dimensions. Observational data has found Chinese toddlers to have higher levels of behavioral inhibition than Canadian toddlers (Chen et al., 1998). These findings converge with data from parent ratings, in which Taiwanese infants were described as less active, approachable, and adaptable, and more negative in mood than U.S. infants (Hsu, Soong, Stigler, Hong, & Liang, 1981), and Japanese preschoolers were reported to be more withdrawal-oriented, less flexible, and to express less positive affect than U.S. children (Windle, Iwawaki, & Lerner, 1988). Super et al. (2008) demonstrated a pattern of similarities, as well as differences, in parental perceptions of 3–8 year-old children across seven cultures. Their findings indicated lower sensitivity, distractibility, and "difficulty" in children from Sweden, higher regularity in Dutch children, and higher distractibility in Australian children, in comparison to youth from other nations. These authors additionally examined links between global ratings of difficulty and specific temperament dimensions, noting, for example, that for Italian mothers only, overall temperamental difficulty was linked with the dimensions of Approach and Adaptability, but not related to negative emotionality.

Because cross-cultural investigations based in the psychobiological tradition form the basis of the meta-analytic dataset used in the current effort, we refrain from extensively reviewing the results of these individual studies. Certain papers in this literature warrant attention, however, as they indicate the consistency of findings across the lifespan. Gaias et al. (2012) investigated cross-cultural differences in temperament between infants, children, and adults from the U.S. and Finland. Across all ages, U.S. participants received higher ratings on temperamental fearfulness than Finnish participants, and also demonstrated higher levels of other negative affects at several time points. During infancy and adulthood, Finns tended to score higher on positive affect and elements of temperamental RC. Montirosso et al. (2011) and Cozzi et al. (2013), studying infants and toddlers, respectively, in the U.S. and Italy both reported higher Cuddliness (an aspect of RC) in Italian children and greater High Intensity Pleasure (an aspect of SUR) in US children. Slobodskaya et al. (2013) compared infants and toddlers from Russia, Japan and the US, reporting similar effects at the two stages for multiple scales, with US children scoring higher than Russian and Japanese children on SUR, and Japan scoring higher than Russian and US children on NEG.

The distribution of personality traits across cultures has been shown to be a function of region, with geographically proximate cultures tending to have more similar profiles, and pronounced differences emerging between different regions. McCrae (2001, 2002; Allik & McCrae, 2004) analyzed self-report data gathered with the NEO-PI-R (Costa & McCrae, 1992) in 36 cultures, revealing systematic effects in which Europeans demonstrate higher levels of E and O scores relative to Asian and African cultures. Additionally, Northern European cultures tended to demonstrate higher levels of Neuroticism than Southern European cultures. McCrae, Terracciano et al. (2005a, 2005b) gathered reports from college students in 51 cultures regarding someone from their country that they knew. Their results largely replicated those from the self-report data, additionally joining America with European nations with respect to high levels of E and O, and Northern European cultures demonstrating higher C as well as N than Southern European cultures. Recently, McCrae et al. (2010), explored convergence between these adult data and ratings of young adolescents made by college students in 24 cultures. McCrae et al. (2010) demonstrated substantial convergence at the facet level, and for the N and E factors, with only modest consistency for O, A and C. As this differential consistency may represent a developmental phenomenon, with less uniform convergence for adolescents/young adults with respect to O, A, and C, we similarly expect greatest convergence between aggregate adult personality and our temperament scores for Sur-E and Neg-N.

Conceptual and empirically supported correspondence between temperament and personality factors, prior cross-cultural findings from both traditions, and evidence of consistency of cultural effects across different life stages inform our predictions regarding our first two goals. First, we anticipate that the geographical patterns characterizing our data will resemble those obtained in prior studies. Specifically, we expect (1) scores on SUR to be higher in the U.S. and Europe than in Asian countries (2) scores on NEG to be higher in East Asian nations than other countries, and (3) Northern European cultures to be particularly high on RC and low on NEG. Our second goal is to formally test whether cross-cultural patterns obtained for adult personality factors correspond to those in our temperament dataset by correlating aggregate personality data obtained by McCrae (2001, 2002; Allik & McCrae, 2004) with aggregate temperament scores consolidated over cross-cultural studies of temperament. Specifically, we expect that aggregate temperament scores for SUR will be positively correlated with aggregate personality scores for E and O, scores for NEG will be

positively correlated with those for N, and scores for RC will be positively correlated with those for C and A.

### 1.4. Cultural orientation and personality

Cultures are known to differ in terms of the values with which their members identify, and related behaviors, with the most frequently used framework for describing such differences developed by Hofstede (1984, 2001, 2011; Hofstede, Hofstede, & Minkov, 2010; Minkov, 2007). Their six "dimensions of national cultures" (Power Distance, Uncertainty Avoidance, Individualism/Collectivism, Masculinity/Femininity, Long-Term/Short-Term Orientation, and Indulgence/Restraint) are statistically and conceptually distinct from one another, and have been validated through their links to a number of economic, political, social and geographical factors. Importantly for the purposes of the current study, they have also been linked to personality dimensions (Hofstede & McCrae, 2004), accounting for a substantial amount of variance. For instance, Hofstede and McCrae (2004) found Individualism to account for 39% of the variance in countries' average scores on Extraversion, and explained 55% of the variance in N through the combination of Uncertainty Avoidance and Masculinity.

*Individualism-Collectivism* represents the most commonly applied construct in explaining cultural differences (Triandis & Suh, 2002). The individualist pole of this dimension is defined by an emphasis on caring for self and one's immediate family, with collectivism instead focused on the wellbeing of the larger group with which one identifies. Individualism tends to be pronounced in Western societies, with collectivism more frequently characterizing Eastern cultures (Hofstede et al., 2010). With respect to personality, Individualism is most strongly associated with E, and has also been linked to high self-reported O and other-reported A (Hofstede & McCrae, 2004; McCrae, 2001; McCrae et al., 2005a).

*Power Distance* speaks to the acceptance of inequality in power in a society, by the followers as well as by the leaders. Geographically, Power Distance tends to be higher in East European, Latin, and Asian countries, with low scores typically found in Germanic and English-Speaking countries (Hofstede et al., 2010). High Power Distance was correlated with low levels of E and O, along with high levels of self-reported C and low levels of other-reported A (Hofstede & McCrae, 2004; McCrae, 2001; McCrae et al., 2005a).

*Masculinity-Femininity* defines the extent to which a society is driven by competition, achievement, and success, rather than cooperation, modesty, nurturance, and a focus on consensus. Whereas Masculinity ratings tend to be high in Japan, German-speaking countries and some Latin nations, very low levels have been reported for Nordic countries and the Netherlands (Hofstede et al., 2010). Self-reported N and O were positively correlated with Masculinity, and a negative association was reported for A (Hofstede & McCrae, 2004).

*Uncertainty Avoidance* reflects the extent to which society members are threatened by unstructured situations that are novel, unknown, surprising, or unusual. Scores on this dimension tend to be higher in countries in Latin America, East and Central European countries, as well as Japan; with lower scores frequently found in English-speaking, Nordic, and Chinese cultures (Hofstede et al., 2010). Individuals in high Uncertainty Avoidance cultures have been characterized as more "emotional" (Hofstede, 2011), and this description appears consistent with personality research finding this dimension to be positively associated with both self- and other-reported N, and negatively with self-reported A (Hofstede & McCrae, 2004; McCrae, 2001; McCrae et al., 2005a).

*Long-term vs short-term orientation* and *indulgence vs restraint* are recent additions to Hofstede's model, and to our knowledge, have not yet been studied in relation to temperament or personality. Cultures scoring high on Long-Term Orientation emphasize values of persistence, thrift, and having a sense of shame, along with ideals which promote the achievement of distant goals. In contrast, cultures of Short-Term Orientation place more emphasis on reciprocating favors and protecting one's 'face' to satisfy more immediate desires (Hofstede et al., 2010). Long-Term Orientation has been strongly linked to East Asian countries with a history of Confusionism, and is also somewhat high in countries in East and Central Europe, whereas countries in North and South America demonstrate more Short-Term Orientation. Indulgence is a cultural dimension that reflects the degree to which a given society allows members to be unrestrained, and represents societal allowance of gratification and an emphasis on hedonic pursuits. Individuals from countries high on this dimension are likely to rate themselves as "very happy" and to remember positive emotions. In contrast, Restraint represents societies with strict codes of conduct and expectations of control of gratification (Hofstede et al., 2010). Restraint is highest in Eastern Europe and Asia, and Indulgence is more pronounced in the Americas and Western Europe. With respect to temperament, both Long-Term Orientation and high Restraint may correspond to RC, as components of this temperament trait include inhibitory control and satisfaction with sedate pursuits, qualities important for patience required to subjugate primary goals in the service of secondary ones. Short-Term Orientation and Indulgence may be linked to high SUR, a trait bound in reward-seeking and frequently impulsive approach tendencies, as well as exuberant, high-intensity pleasure.

Our predictions regarding links between temperament and culture, based in similarity between psychobiological and Big Five traits, previous studies of culture and personality, and conceptual implications of regulatory and reactive dimensions for the pursuit of differing goals, can be summed up as follows. SUR is expected to be associated with high Individualism, low Power Distance, Masculinity, Short-Term Orientation, and Indulgence. NEG is expected to be linked to high Uncertainty Avoidance and Masculinity. Predictions regarding RC are more tentative, due to conflicting findings for C and A in relation to culture. Predictions based in C suggest RC will be highest in individuals from countries characterized by high Power Distance. Those based in A suggest RC will be linked to low Power Distance, Uncertainty Avoidance, and Masculinity. We also predict RC will be associated with Long-Term Orientation and Restraint.

### 1.5. Genes, individual differences, and culture

Whereas cultural orientation represents a pervasive set of environmental effects that can explain patterns of differences between persons from different areas of the globe, such differences are likely to be additionally influenced by genetic variation between populations. Although concerns have been raised about candidate gene research with respect to understanding origins of health and disease, a number of Single Nucleotide Polymorphism (SNPs) have been consistently implicated in multiple domains of temperament, and linked with culture. SNPs are DNA sequence variations occurring commonly within a population in which a single nucleotide in the genome differs between members of a biological species or paired chromosomes. SNPs found within a gene, or in a regulatory region near a gene, are thought to play a more direct role in affecting the gene's functioning. Genes associated with neurotransmitter functioning are most relevant to temperament, and three such SNPs will be considered here.

*5-HTTLPR* (serotonin-transporter-linked promoter region) is a repeat polymorphic region of SLC6A4, the gene that encodes for the serotonin transporter, and occurs in the promoter region responsible for the initiation of transcription (Collier et al., 1996; Heils et al., 1996). The SLC6A4-linked polymorphic region or

5-HTTLPR consists of two common alleles: a short (S) variant with 14 copies, and a long (L) variant with 16 copies of a 44 bp repeat element (Kraft, Slager, McGrath, & Hamilton, 2005; Lesch et al., 1996).

Multiple studies have explored relations between 5-HTTLPR and social-emotional functioning in adults and children. The results of these studies, including those regarding temperament, however, have been relatively inconsistent. As noted by Saudino and Wang (2012), the 5-HTTLPR has been linked to both high and low levels of emotionality and shyness, with the polymorphism also connected to a wide variety of other temperament dimensions, including activity level, attention, and reward dependence. Chiao and Blizinsky (2010) interpreted existing findings as suggesting that the S allele of 5-HTTLPR was associated with heightened negative emotions, extending investigation in a cross-cultural direction. The S allele is carried by approximately 70–80% of individuals in East Asian regions, in comparison to European samples in which about 40–45% of people carry this polymorphism (Gelernter, Kranzler, & Cubells, 1997; Nakamura et al., 1997). Chiao and Blizinsky (2010) showed a strong correlation between prevalence of the S allele and Collectivism across 29 nations. Their results also indicated lower levels of anxiety and mood disorders in collectivist and high S allele frequency countries, with regression analysis suggesting that collectivism mediated the connection of S allele prevalence with anxiety and mood disorder frequency (Chiao & Blizinsky, 2010). Minkov et al. (2015) questioned the findings of Chiao and Blizinsky (2010) in relation to Collectivism, noting that S allele prevalence is particularly low in sub-Saharan Africa, a region with several highly collectivist societies. Using an expanded dataset including a more geographically diverse set of countries, Minkov et al. (2015) did not confirm Chaio and Blizinsky's findings regarding collectivism. Minkov et al. (2015) did, however, find high prevalence of S alleles to be associated with national scores for Neuroticism and Hofstede's Long-Term Orientation dimension.

*A118G (m-opioid receptor)* is a SNP within the MOPR gene (OPRM1). Opioid receptors (MOPRs) are key agents in regulation of emotional states, modulating positive and negative affect, for example in situations involving social reward and rejection (Hsu et al., 2013; Trezza, Damsteegt, Achterberg, Louk, & Vanderschuren, 2011). A variety of animal models have been used to demonstrate that genetic mutations of the MOPRs alter receptor function, in turn influencing social behavior (Barr et al., 2008; Moles, Kieffer, & D'Amato, 2004).

The G allele (i.e., A118G) has been linked with a mixed set of outcomes, in so far as carriers were shown to become engaged in affectionate relationships more easily, experiencing relatively greater pleasure from social interactions (Troisi et al., 2011), but at the same time, increased sensitivity to social rejection has also been demonstrated in G-allele carriers (Bertoletti, Zanoni, Giorda, & Battaglia, 2012; Way, Taylor, & Eisenberger, 2009). With respect to personality, G-carriers self-reported higher Neuroticism scores compared to AA homozygote carriers (Peciña, Love, Stohler, Goldman, & Zubieta, 2015). Whereas the G allele is fairly common in European (15–30%) and Asian (49–60%) populations, it appears relatively more frequently in the latter (Bergen et al., 1997; Gelernter, Kranzler, & Cubells, 1999; Tan, Tan, Karupathivan, & Yap, 2003). Way and Lieberman (2010) suggested that the G allele was associated with "social sensitivity", and explored population prevalence of the allele in relation to Collectivism, finding higher proportions of the G allele were associated with higher collectivism, and with lower depression rates, across 26 countries, with collectivism partially mediating the link between A118G and depression.

*MAOA-uVNTR (MAOA concentration)* gene expression controls functioning of the monoamine oxidase type A (MAOA) enzymes, which play a key role in neural plasticity. Two common allelic variants of this gene have been identified: high-activity MAOA (HAM) and low-activity MAOA (LAM) in the upstream Variable Number Tandem Repeat (MAOA-uVNTR) region. The MAOA-uVNTR has been associated with multiple mental health conditions in childhood and adulthood, including major depressive disorder (Lung, Tzeng, Huang, & Lee, 2011; Rivera et al., 2009), panic disorder (Reif et al., 2012), aggression (Byrd & Manuck, 2014) and attention deficit hyperactivity disorder (ADHD; Guan, Wang, & Chen, 2009; Nymberg et al., 2013). Way and Lieberman (2010) conceptualized the LAM as another marker of social sensitivity. Similar to their analyses of A118G and 5-HTTLPR, prevalence of the LAM allele was higher in collectivist societies, and collectivism mediated links between gene prevalence and depression.

In sum, research on allelic distribution in relation to culture has identified variants of three different genes whose prevalence correlates with Neuroticism, and with rates of anxiety and mood disorders. In the current study, we assess connections between the prevalence rates of these genes and aggregate temperament scores. Because high NEG, low RC, and low SUR are associated with internalizing problems in children (Gartstein, Putnam, & Rothbart, 2012), and Neuroticism is conceptually linked to NEG, we predict that NEG will be highest, and RC and SUR will be lowest in countries with high proportions of individuals carrying the S allele of 5-HTTLPR, the G allele of A118G, and the LAM allele of MAOA-uVNTR.

### 1.6. Summary of goals and predictions

The initial objective of the present study is to address the limitations of the existing literature by consolidating cross-cultural data across multiple investigations in order to discern patterns of regional variability in temperament. We expected that scores on SUR would be higher in the U.S. and Europe than Asian countries, scores on NEG would be higher in East Asian nations than other countries, and Northern European cultures would be particularly high on RC and low on NEG. Second, we addressed the correspondence between culture and individual differences investigated through two different lenses, namely the study of adult personality and temperament development. We expected that aggregate temperament scores for SUR would be positively correlated with aggregate personality scores for E and O; NEG would be positively associated with scores for N; and RC would be positively correlated with C and A. The third goal was to explore links between cultural orientation dimensions and temperament characteristics across the cultures included in our investigations. SUR was expected to be associated with high Individualism, low Power Distance, Masculinity, Short-Term Orientation, and Indulgence, and NEG to be linked to high Uncertainty Avoidance and Masculinity, with more tentative predictions offered concerning the RC factor, due to inconsistent findings for Conscientiousness and Agreeableness in relation to culture. Finally, we set out to explore potential genetic contributions to cultural differences in child temperament. Specifically, we explored whether the patterns of previously reported allelic distributions correspond to variability in aggregate temperament traits characterizing different regions involved, hypothesizing that NEG would be highest, and RC and SUR lowest, in countries with high proportions of individuals carrying the S allele of 5-HTTLPR, the G allele of A118G, and the LAM allele of MAOA-uVNTR.

## 2. Material and methods

### 2.1. Aggregate temperament

Temperament data were obtained from 10 published and 7 unpublished (conference presentations) cross-cultural studies

concerning individuals from 18 nations. To be included in the current analyses, each study was required to have conducted comparisons of temperament scores between the U.S. and at least one other country, measured in individuals of the same age, with instruments developed in the psychobiological tradition: the Infant Behavior Questionnaire (IBQ; Rothbart, 1981); Infant Behavior Questionnaire-Revised (IBQ-R; Gartstein & Rothbart, 2003); Early Childhood Behavior Questionnaire (ECBQ; Putnam et al., 2006); Child Behavior Questionnaire (CBQ; Rothbart et al., 2001); or Adult Temperament Questionnaire (ATQ; Evans & Rothbart, 2007). A search of PsycInfo using the terms "temperament" and "culture" revealed no empirical papers meeting these criteria other than those included in the current paper. Table 1 contains a list of all studies, including the instruments used and countries examined.

Aggregate factor scores for each country were derived in a three-step process. First, Cohen's *d* effect sizes were calculated for each scale within each country-specific subsample, representing that culture's score in relation to the score for the U.S. subsample (as such, the score for the U.S. on all scales is 0). In cases for which data gathered with a given instrument (e.g., the IBQ-R) had been analyzed in more than one paper or publication for a particular country, scale scores were averaged across relevant investigations. Second, instrument-specific factor scores were created by averaging the Cohen's *d* scale scores affiliated with each factor. For instance, for infant samples, the IBQ-R SUR score was the mean of Activity Level, Approach, High-Intensity Pleasure, Perceptual Sensitivity, and Vocal Reactivity *d* scores. Finally, for the ten countries that had been studied using more than one instrument, factor scores from each measure were averaged to create a single aggregate score for each country on each factor.

### 2.2. Aggregate personality

Average scores for individuals from the countries studied on the five factors assessed with the NEO Personality Inventory were obtained from prior studies. McCrae (2001, 2002) examined cultural differences in self-reported personality from 36 countries, including 12 for which we have aggregate temperament scores, and McCrae et al. (2005a) gathered data from college students asked to rate an individual from their country that they knew well, assessing other-reported personality in 51 cultures, including 12 for which we have aggregate temperament scores. Countries represented in our analyses of both self- and other-reported aggregate personality in relation to aggregate temperament include Belgium, China, Denmark, Germany, Italy, Japan, Russia, South Korea, Spain, and the U.S. Other-report, but not self-report, was available for Chile and Poland. Self-report, but not other-report, scores were available for the Netherlands and Taiwan. Self-report estimates are based on samples ranging from 196 to 3730 per country (see McCrae, 2002). Other-report estimates are based on samples ranging from 177 to 919 per country (see McCrae et al., 2005a).

### 2.3. Cultural dimensions

Values for Hofstede's six dimensions (Individualism-Collectivism, Masculinity-Femininity, Uncertainty Avoidance, Power Distance, Long Term Orientation-Short Term Orientation and Indulgence-Restraint), initially published by Hofstede (2001) and Hofstede et al. (2010) were obtained from http://www.geerthofstede.nl/research–vsm on July 22, 2015. Scores for the initial four dimensions are based on analyses of over 100,000 questionnaires completed by IBM employees, with scores on Long-Term Orientation and Indulgence-Restraint obtained from World Values Survey data obtained from several thousand respondents. Scores for all cultural dimensions were available for 15 of the 18 countries represented in our analyses. No cultural dimension scores were available for Curacao; scores for Long Term Orientation-Short Term Orientation were not available for Suriname; and Indulgence-Restraint scores were not available for Suriname nor Israel.

**Table 1**
Summary of cross-cultural studies from which temperament scores were obtained.

| Authors and year | Age group (instrument) | Countries other than U.S. included |
|---|---|---|
| *Published* | | |
| Ahadi et al. (1993) | Children (CBQ) | China |
| Cozzi et al. (2013) | Toddlers (ECBQ) | Italy |
| Gaias et al. (2012) | Infants (IBQ[a]), Children (CBQ), Adults (ATQ) | Finland |
| Gartstein et al. (2006) | Infants (IBQ[a]) | China, Spain |
| Gartstein, Peleg, Young, and Slobodskaya (2009) | Infants (IBQ-R) | Israel, Russia |
| Gartstein et al. (2003) | Infants (IBQ-R) | Russia |
| Gartstein, Slobodskaya, Żylicz, Gosztyla, and Nakagawa (2010) | Infants (IBQ-R[b]) | Japan, Poland, Russia |
| Montirosso et al. (2011) | Infants (IBQ-R[c]) | Italy |
| Slobodskaya et al. (2013) | Infants (IBQ-R), Toddlers (ECBQ) | Japan, Russia |
| Sung et al. (2015) | Infants (IBQ-R) | Netherlands |
| *Unpublished* | | |
| Casalin, Putnam, and Gartstein (2013) | Infants (IBQ-R[d]), Toddlers (ECBQ[d]) | Belgium |
| Gartstein et al. (2009) | Infants (IBQ[a]) | China, Spain, Finland |
| Kirchhoff et al. (2013) | Toddlers (ECBQ) | Germany |
| Komsi et al. (2009) | Adults (ATQ[e]) | Finland, Belgium, USA, Chile |
| Krassner, Krogh, Vaever, Putnam and Gartstein (2014) | Toddlers (ECBQ) | Denmark |
| Krassner et al. (2016) | Toddlers (ECBQ) | Chile, South Korea, Poland |
| Majdandzic et al. (2009) | Children (CBQ) | Curacao, Germany, Netherlands, Suriname, Taiwan |

Notes:
[a] The IBQ includes only six of the fourteen scales found on the larger IBQ-R.
[b] Gartstein et al. (2010) did not find effects of culture on scales assessing Duration of Orienting, Cuddliness, Low-Intensity Pleasure and Soothability, so did not report culture-specific statistics for these scales.
[c] Montirosso et al. administered an experimental version of one scale (Cuddliness) and did not include this scale in their analyses.
[d] Casalin et al. (2013) did not administer seven of the fourteen scales from the IBQ-R (Activity Level, Falling Reactivity, Low-Intensity Pleasure, Perceptual Sensitivity, Sadness, Soothability and Vocal Reactivity) and nine of the eighteen scales from the ECBQ (Activity Level, Attention Shifting, Discomfort, Low-Intensity Pleasure, Motor Activation, Perceptual Sensitivity, Sadness, Sociability, and Soothability).
[e] Komsi et al. reported factor scores, not scores for individual scales.

### 2.4. Allelic frequency

Data on allelic frequency of the short variant of the 5-HTTLPR gene were obtained from Chiao and Blizinsky (2010), who compiled these proportional data for 29 countries through a review of 124 peer-reviewed publications studying a total of 50,135 individuals; and Minkov et al. (2015), who expanded the database provided by Chiao and Blizinsky (2010) using data compiled by Murdoch, Speed, Pakstis, Heffelfinger, and Kidd (2013) on approximately 2500 individuals, to cover 59 countries, including 16 represented in our analyses: Belgium, Chile, China, Denmark, Finland, Germany, Israel, Italy, Japan, Korea, the Netherlands, Poland, Russia, Spain, Taiwan and the U.S. Data on allelic frequency of the G allele of the A118G polymorphism of the μ-opioid receptor gene and the low expression allele of the MAOA-uVNTR polymorphism were obtained from Way and Lieberman (2010), who used an approach similar to that employed by Chiao and Blizinsky (2010), basing estimates on a combined sample of approximately 5000 individuals over 19 countries. Data for frequency of both A118G and MAOA-uVNTR were available for 8 of our 18 countries: China, Denmark, Germany, Italy, Japan, the Netherlands, Taiwan, and the U.S. Data regarding A118G frequency were additionally available for Finland, South Korea, and Russia, and MAOA-uVNTR frequency data were also available for Poland.

### 2.5. Gross National Income per capita

Following Hofstede and McCrae (2004), who included Gross National Income per capita as a control variable when exploring relations between aggregate personality and cultural orientation, estimates of Gross National Income per capita (calculated with Atlas method; averaged from 1999 through 2014) was obtained for 16 countries (excluding Taiwan and Curacao) from http://data.worldbank.org/indicator/NY.GNP.PCAP.CD. An estimate for Taiwan was created by extrapolating from 2011 GNP-PPP data obtained from http://www.nationsonline.org/oneworld/GNI_PPP_of_countries.htm.

## 3. Results

### 3.1. Aggregate temperament descriptive statistics

Aggregate temperament scores on SUR, NEG, and RC for each country are presented in rank order in Table 2. To facilitate comparisons of geographical regions, these values are reflected in shading on Fig. 1.

**Table 2**
Aggregate temperament scores for countries studied.

| Surgency | | Negative affectivity | | Regulatory capacity | |
|---|---|---|---|---|---|
| Country | Factor score | Country | Factor score | Country | Factor score |
| Denmark | 0.41 | Chile | 0.41 | Denmark | 0.52 |
| Israel | 0.39 | Korea | 0.38 | Netherlands | 0.47 |
| Finland | 0.09 | Japan | 0.33 | Israel | 0.44 |
| Chile | 0.07 | Poland | 0.29 | Finland | 0.32 |
| Spain | 0.06 | Russia | 0.21 | Korea | 0.30 |
| USA | 0.00 | Spain | 0.18 | Germany | 0.26 |
| Suriname | −0.01 | Italy | 0.16 | Curacao | 0.23 |
| Poland | −0.10 | Taiwan | 0.11 | Spain | 0.20 |
| Germany | −0.12 | China | 0.09 | Belgium | 0.13 |
| Korea | −0.13 | Germany | 0.01 | Chile | 0.05 |
| Italy | −0.16 | USA | 0.00 | Russia | 0.03 |
| Taiwan | −0.22 | Suriname | −0.02 | USA | 0.00 |
| Russia | −0.23 | Israel | −0.11 | Suriname | −0.02 |
| Netherlands | −0.24 | Belgium | −0.30 | Italy | −0.04 |
| Japan | −0.24 | Finland | −0.36 | Poland | −0.15 |
| Belgium | −0.25 | Curacao | −0.38 | Taiwan | −0.24 |
| China | −0.59 | Netherlands | −0.67 | Japan | −0.35 |
| Curacao | −0.61 | Denmark | −0.86 | China | −0.80 |

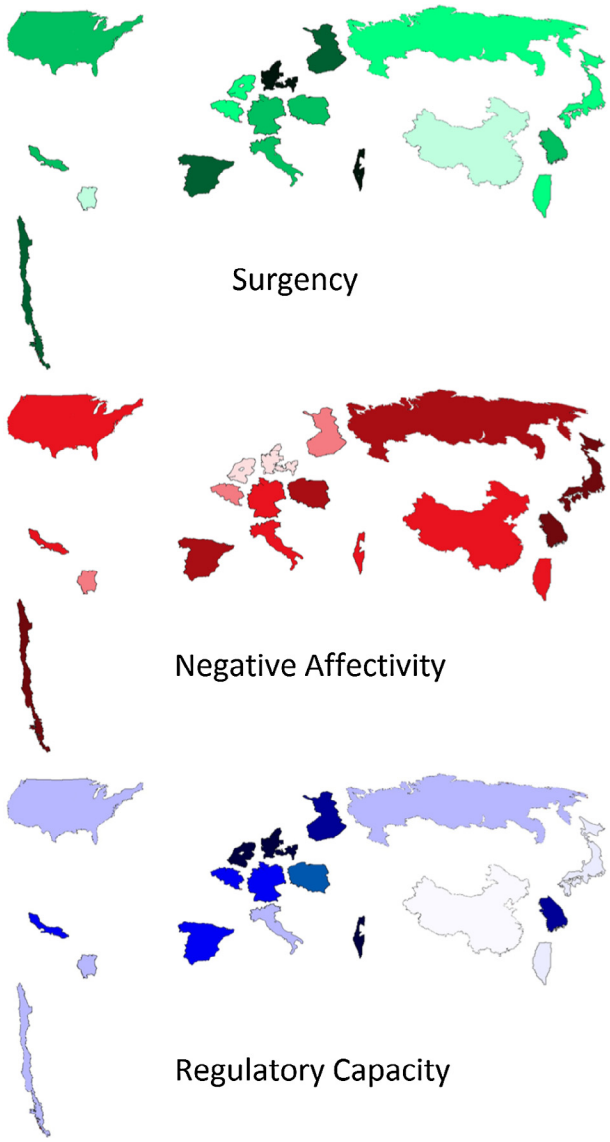


**Fig. 1.** Geographic distribution of aggregate temperament scores. Darker shading represents higher scores.

Geographical trends are obscure for SUR. Although the highest score for SUR was associated with Denmark, other European countries were average (e.g., Germany) or relatively low (e.g., Belgium) on this factor; although Curacao demonstrated the lowest levels of SUR, other American cultures (e.g., USA) were relatively high. A degree of consistency was, however, evident with respect to East Asian nations: China demonstrated very low SUR; and Japan, Taiwan and South Korea were all in the bottom half of the distribution.

Asian and East European countries tended to also be consistent in their levels of NEG. Four of the five highest scores came from Korea, Japan, Russia and Poland; and Taiwan and China were also in the top half of the distribution. Northern European nations tended to demonstrate low NEG, with Denmark, Netherlands, Finland and Belgium representing four of the five lowest scores. Countries of the Americas demonstrated no clear pattern: Chile received the highest score on this factor, Curacao was among the lowest-scoring, and USA and Suriname were near the middle of the distribution.

**Table 3**
Correlations between aggregate personality and aggregate temperament scores.

| | Surgency | Negative affectivity | Regulatory capacity |
|---|---|---|---|
| *Extraversion* | | | |
| Self | 0.65* | −0.57# | 0.36 |
| Other | 0.60* | −0.34 | 0.53# |
| *Neuroticism* | | | |
| Self | −0.38 | 0.82* | −0.40 |
| Other | 0.46 | 0.03 | 0.46 |
| *Conscientiousness* | | | |
| Self | −0.11 | −0.12 | −0.05 |
| Other | 0.27 | 0.29 | 0.26 |
| *Openness to experience* | | | |
| Self | −0.30 | −0.01 | 0.24 |
| Other | 0.43 | −0.54# | 0.45 |
| *Agreeableness* | | | |
| Self | 0.24 | −0.49 | 0.45 |
| Other | 0.67* | −0.52# | 0.75* |

Note: n = 12.
* p < 0.05.
# p < 0.10.

Nations from Northern Europe were consistently high in RC: Denmark, The Netherlands, and Finland demonstrated three of the highest scores, and Germany and Belgium were in the top half of the distribution. With the exception of South Korea, eastern Asian countries, particularly China, tended to be rated low in RC. Countries in the Americas were relatively moderate in RC.

### 3.2. Aggregate temperament and aggregate personality

Pearson's correlations between aggregate temperament and aggregate personality scores are presented in Table 3. Consistent with expectations, countries characterized by high ratings for temperamental SUR also demonstrated high self-rated and other-rated scores for E. Also as anticipated, high levels of temperamental NEG were found in the same countries showing high self-rated N. High levels of both SUR and RC were associated with high scores on other-rated A. Marginal associations suggested that high NEG was associated with low levels of self-rated E, other-rated O, and other-rated A; and that high levels of REG were linked to high other-rated E.

### 3.3. Aggregate temperament and cultural orientation dimensions

Correlations between aggregate temperament scores and country scores for Hofstede's six cultural orientation dimensions are shown in Table 4. Because we wished to determine whether different cultural orientations predicted unique variance in aggregate temperament scores, controlling for Gross National Product per capita (GNI), results of multiple regression using the six cultural dimensions as predictors are also presented in Table 4.

Regarding SUR with respect to simple correlations, countries in which individuals received high ratings on SUR were characterized by low Power Distance, high Indulgence, low Long-Term Orientation, and, marginally, low Masculinity. The effect for Long-Term Orientation remained significant, with a marginal effect indicating low Masculinity predicting high SUR in the regression model, in which cultural orientation and GNI accounted for 86% of the variance in SUR.

Correlations indicated that countries demonstrating high levels of NEG had cultural orientations reflecting low levels of Individualism and Indulgence; and high levels of Power Distance, Masculinity, and Uncertainty Avoidance. GNI was also negatively correlated with NEG. Masculinity and Uncertainty Avoidance remained significant, and Individualism was marginally significant, as predictors of NEG in the regression model, in which cultural orientation and GNI accounted for 89% of the variance.

In correlational analyses, countries in which individuals were rated as high in RC tended to be low in Power Distance and Masculinity, and, marginally, high in Individualism and Indulgence. GNI was also marginally positively correlated with RC. The effects for Power Distance and Masculinity remained, the effect for Individualism became significant, and high Uncertainty Avoidance emerged as a significant predictor of high Regulatory Capacity in the regression model, in which cultural orientation and GNI accounted for 94% of the variance in RC.

**Table 4**
Correlations and regression coefficients between cultural orientation dimensions and aggregate temperament scores.

| | Surgency | | Negative affectivity | | Regulatory capacity | |
|---|---|---|---|---|---|---|
| | *r* | β | *r* | β | *r* | β |
| Individualism | 0.29 | −0.49 | −0.59* | −0.50# | 0.45# | 0.43* |
| Power distance | −0.65* | −0.42 | 0.56* | −0.16 | −0.63* | −0.79* |
| Masculinity | −0.43# | −0.35# | 0.55* | 0.51* | −0.64* | −0.76* |
| Uncertainty avoidance | −0.06 | 0.31 | 0.60* | 0.42* | −0.02 | 0.52* |
| Indulgence | 0.57* | −0.44 | −0.60* | −0.07 | 0.51# | −0.13 |
| Long term orientation | −0.72* | −0.87* | 0.25 | −0.26 | −0.36 | 0.22 |
| GNI per capita | 0.29 | 0.63 | −0.61* | −0.27 | 0.47* | −0.21 |
| *F* | | 5.96* | | 7.89* | | 15.73* |
| $R^2$ | | 0.86 | | 0.89 | | 0.94 |

Note: Correlation *ns* = 17 for Individualism, Power Distance, Masculinity, Uncertainty Avoidance and GNI, 16 for Long-Term Orientation, and 15 for Indulgence. Regression df = 7, 7.
* p < 0.05.
# p < 0.10.

**Table 5**
Correlations between population frequency of alleles and aggregate temperament ratings.

| | Surgency | Negative affectivity | Regulatory capacity |
|---|---|---|---|
| 5-HTTLPR S-form | −0.46# | 0.47# | −0.55* |
| A118G G-form | −0.45 | 0.58# | −0.61* |
| MAOA-uVNTR low expression | −0.68* | 0.54 | −0.82* |

Note: n = 16 for 5-HTTLPR, n = 11 for A118G, n = 9 for MAOA.
* p < 0.05.
# p < 0.10.

### 3.4. Aggregate temperament and allelic frequency

Correlations between aggregate temperament scores and the proportion of individuals possessing alleles linked to psychological individual differences are shown in Table 5, and scatterplots of significant correlations are presented in Fig. 2. SUR was marginally associated with low frequency of S-form alleles of 5-HTTLPR and significantly associated with low frequency of low expression alleles of the MAOA-uVNTR gene. Marginal correlations were evident indicating high NEG in nations with high proportions of 5-HTTLPR S-form and A118 G-form alleles. RC was significantly associated with low frequency of S-form alleles of 5-HTTLPR, A118 G-form, and low expression MAOA-uVNTR alleles.

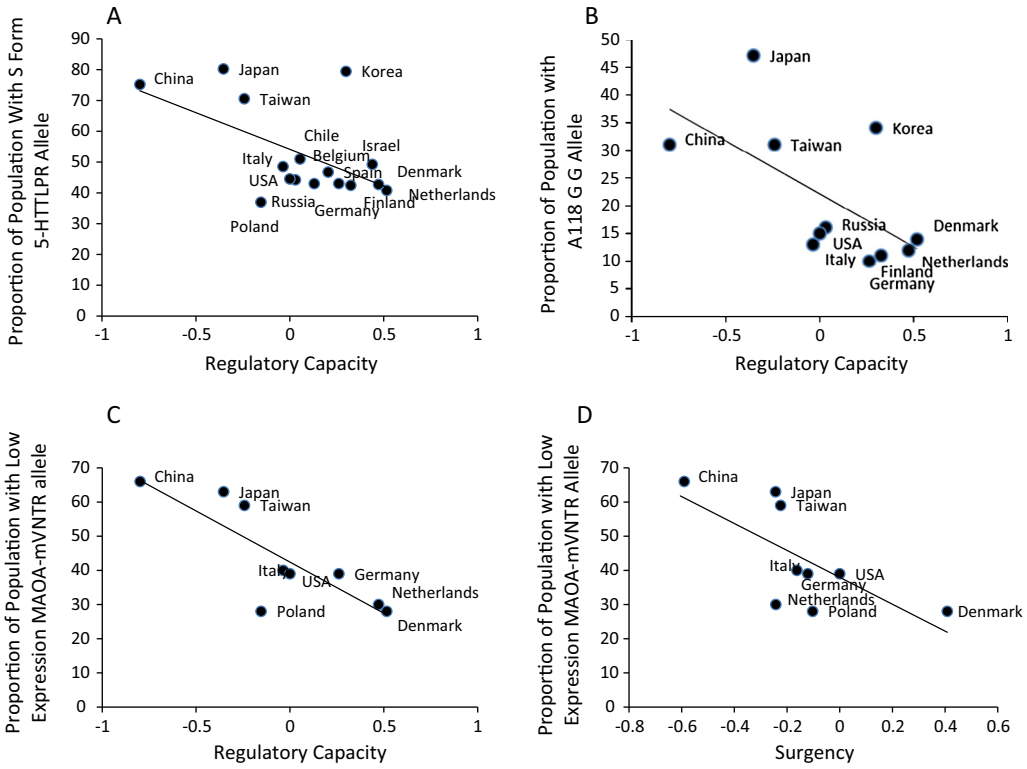


**Fig. 2.** Scatterplots of correlations between allele proportions and aggregate temperament traits. (A) S allele of 5-HTTPLR, (B) G allele of A118G and RC, (C) LAM allele of MAOA-uVNTR and RC, (D) LAM allele of MAOA-uVNTR and SUR.

## 4. Discussion

The overarching goal of the current study was to understand global variation in early-appearing differences between individuals in their reactivity and regulation. To address this goal, we first consolidated data across multiple cross-cultural investigations of temperament in order to discern patterns of geographic differences. We then examined these aggregate temperament scores in terms of their similarity to patterns obtained with personality variables, their associations with cultural orientation dimensions, and correspondence with allelic frequency of SNPs previously identified as important to psychological functioning. This endeavor was unique in its scope, representing far ends of both nature and nurture. Culture is perhaps the most distal representation of the influence of nurture, with macrosystem-level effects transmitted through layers of more proximal processes to influence individual development; correspondingly, genes constitute the most distal manifestation of nature, with their impact translated through cellular, neural and physiological mechanisms as maturation unfolds. Only a handful of investigations have attempted to connect these disparate forces (e.g., Chiao & Blizinsky, 2010; Gonda, Vazquez, Akiskal, & Akiskal, 2011; Way & Lieberman, 2010), and none, to our knowledge, have integrated them in the context of infant and child temperament.

### 4.1. Geographic patterns of temperament

Our descriptive geographical analysis was intended to address a significant gap in existing research, addressing a number of limitations, such as studying narrow individual dimensions (e.g., shyness; Chen et al., 1998) and bi-cultural comparisons (e.g., Gartstein, Slobodskaya, & Kinsht, 2003). Using data from 18 countries and 17 studies, global patterns of differences for the three temperament factors (SUR, NEG, and RC) derived on the basis of the psychobiological model were considered. With respect to SUR, a consistent pattern emerged, insofar as East Asian cultures demonstrated relatively low levels of this attribute, with China scoring very low; and Japan, Taiwan, and South Korea all in the bottom half of the distribution. NEG levels were also similar across Asian cultures, as some of the highest scores were observed in Korea and Japan, with Taiwan and China also in the top half of the distribution. Relatively low NEG was observed across Northern Europe, with Denmark, Netherlands, Finland and Belgium representing four of the five lowest scores. The low Negativity apparent in Northern Europe was complemented by high levels of RC, as Denmark, the Netherlands and Finland were among the highest scoring countries. China scored very low in RC, which was also low in Taiwan and Japan.

These geographic patterns are not surprising, given results of existing research. For example, Taiwanese infants were rated lower by their parents on activity and approach associated with SUR, relative to their US comparison sample (Hsu et al., 1981), and Japanese preschoolers were described as exhibiting less positive affect than U.S. children (Windle et al., 1988). Findings of higher levels of shyness and lower sociability for samples from Asian cultures, relative to their Western counterparts (e.g., Chen et al., 1998; Hart et al., 2000), also appear consistent with lower SUR observed for the Asian cultures in this study, in so far as shyness involves low levels (or inhibited) approach tendencies associated with positive emotionality (Putnam & Stifter, 2005). Few cross-cultural studies of temperament have explicitly addressed aspects of regulation, but our findings of high regulatory capacity among individuals in Northern Europe complement those of low distractibility in Swedish children (Super et al., 2008), and the tendency for parents of Dutch infants to describe their children as demonstrating long attention spans (Harkness & Super, 2006).

### 4.2. Correspondence between cross-cultural patterns of temperament and personality

A more formal evaluation of consistency with prior research was possible with respect to concordance between aggregate personality and temperament ratings. Our results are in accord with other studies documenting similarity between scores derived on the basis of the 5-factor personality model and those obtained from temperament instruments based in the psychobiological framework (e.g., Rothbart et al., 2000). As hypothesized, high levels of SUR overlapped geographically with high self-rated/other-rated E scores. High NEG was observed across the same cultures as those with members self-reporting high Neuroticism, whereas high SUR and RC were associated with high levels of other-rated A. These findings, indicative of similar patterns across personality and temperament domains with respect to their geographic distributions, support the inference of commonality of constructs assessed in these two traditions. Importantly, this pattern of results suggests that adult personality factors have roots in processes observed in childhood and infancy. Stability of individual differences has been reported as early as the first year of life (Bornstein et al., 2015), nonetheless, temperament tends to be less stable early in life, presumably because the period of infancy to preschool age is a time of major changes in the regulative aspects of temperament (Posner, Rothbart, Sheese, & Voelker, 2012). Not surprisingly, stability has been demonstrated over longer time intervals later in childhood and adulthood. For instance, continuity between earlier surgency and later positive emotionality was demonstrated from 8–12 years to 20 years of age (Shiner, Masten, & Tellegen, 2002), and Kubzansky, Martin, and Buka (2004) found that anger/hostility at 7 years of age predicted adult measures of this attribute.

Links between temperament and personality indicators observed across diverse geographic regions in this study, as well as relationships among these individual differences reported elsewhere (e.g., Evans & Rothbart, 2007), reflect homotypic continuity, referring to similar behaviors over time, as well as heterotypic continuity, wherein an underlying developmental process is constant over time, yet its manifestations vary somewhat with development (Caspi, 1998). Although the majority of studies concerning differential continuity of temperament and personality have addressed homotypic continuity, there are a number of examples of heterotypic continuity in the literature. Kagan, Snidman, and Arcus (1998) reported that reactive 4-month-old infants (exhibiting high levels of negative affect and activity in response to novel stimuli) tended to avoid interaction with peers at 4 years of age. In another example, Putnam, Rothbart, and Gartstein (2008) found that toddler Effortful Control was predicted by both SUR and Orienting/Regulatory Capacity measured during infancy. The present findings suggests homotypic continuity for SUR/Extraversion and NEG/Neuroticism, along with heterotypic continuity for A, with higher SUR and RC linked to a more agreeable presentation across cultures/geographic regions considered in this study.

### 4.3. Temperament and cultural orientation

Connections between characteristics of the individual and the broad context in which they exist were then explored via relations between aggregate temperament scores and cultural dimensions. Whereas prior research has tended to emphasize collectivism and individualism, in this work we considered a number of additional dimensions identified by Hofstede (e.g., Hofstede et al., 2010) to provide a more thorough perspective on the interplay between temperament and culture. Each of the cultural orientation dimensions investigated was shown to make unique contributions to one or more of the three temperament dimensions. It is notable that the cultural dimensions explained a considerable amount of variance in the three temperament factors after accounting for variance associated with Gross National Income per capita, and that the predictive constellation of cultural dimensions varied depending on the temperament factor examined. The former speaks to the strength and importance of this connection, as significant associations were demonstrated for the GNI on two of the three temperament factors, indicating lower NEG and higher RC for cultures with higher average incomes. The latter profile of distinct predictive relationships suggests specificity with respect to the associations between cultural orientation dimensions and individual differences. Overall, our results indicate the under-investigated domains of cultural orientation capture important distinctions that govern aspects of personal interaction and/or socialization goals, ultimately helping to shape individuals living within these systems.

Higher SUR was associated with low Power Distance and Long-Term Orientation, and with high Indulgence. Hofstede has suggested that "a society's power distance level is bred in its families through the extent to which its children are socialized toward obedience or toward initiative" (Hofstede & McCrae, 2004, p. 62), and the observed pattern of results supports this view, as well as the idea that growing up in Short-Term Oriented and Indulgent cultures creates exposure to norms geared toward the immediate gratification of needs (Hofstede et al., 2010). Our findings suggest that cultures in which individuals are compelled to accept the existence of inequity and to focus on distant goals rather than indulgence of immediate gratification may discourage the expression of approach tendencies that promote initiative and pleasure through intense sensations.

Higher NEG was apparent in cultures marked by orientations of Collectivism, Masculinity, and Uncertainty Avoidance, with more tentative associations with high Power Distance, low Indulgence and Short-Term Orientation. Several studies have indicated relatively greater emotional reactivity in children and adults from Asian than Western countries (Chen, Yang, & Fu, 2012), and our findings suggest that these trends extend to other highly Collectivist countries such as Chile. Socialization in collectivistic cultures has been described as focusing on emotional warmth and proximity that fosters acceptance of the group's norms and values (Keller et al., 2004). Caregivers in more collectivistic societies often respond to their infants' needs in an anticipatory manner, blurring the self-other distinction, whereas caregivers in individualistic cultures tend to encourage the expression of positive emotions and focus on early flexible self-regulation (Greenfield, Keller, Fuligni, & Maynard, 2003; Keller et al., 2004). Our findings suggest that such practices may enhance the likelihood of expression for negative affect in children from cultures with a greater emphasis on collectivistic values. Our results regarding Uncertainty Avoidance and Masculinity converge with findings of higher N in adults from countries characterized by these orientations (Hofstede & McCrae, 2004). Uncertainty Avoidance, the degree to which societies provide structure to avoid distress-promoting events, might be expected to emerge in societies in which individuals tend to experience distress more frequently. Cultural Masculinity, associated with the pursuit of personal goals over relational ones, may result in cultures in which children are left to, or even encouraged to, express negative emotions more strongly.

High levels of RC were associated with low Power Distance and Masculinity, as well as high Individualism and Uncertainty Avoidance. Hofstede (2011) suggests that parents treat children more as equals, rather than demanding obedience, in low Power Distance societies, a practice that may promote precocious regulation; yet, our findings are contrary to those indicating high Power Distance is associated with Conscientiousness in adults, suggesting

variability in these links across the lifespan. Relationship-oriented parenting in Feminine societies may encourage cuddling and pleasure in low-intensity contexts, attributes associated with RC. Findings regarding high RC and Individualism, significant only after partialling out other cultural influences, are surprising with respect to prior studies indicating more advanced gratification delay and executive function in Chinese and Korean than US children (Oh & Lewis, 2008; Sabbagh, Xu, Carlson, Moses, & Lee, 2006). In addition, our findings concerning the link between high Uncertainty Avoidance and high RC are not consistent with Hofstede (2011) describing individuals in high Uncertainty Avoidance cultures as more "emotional", or with adult personality studies indicating this cultural dimension is positively associated with N (Hofstede & McCrae, 2004; McCrae, 2001; McCrae et al., 2005a). The observed pattern of results may be indicative of developmental differences, and should be replicated in future research.

### 4.4. Temperament and allelic distribution

Correlations between aggregate temperament scores and the proportion of individuals possessing alleles linked to individual differences in relevant neuropsychological functions were documented, with several significant and trend-level effects resulting from the small sample size available for the purposes of this aspect of the study. The observed pattern of results was consistent with our expectations. Specifically, whereas SUR was linked to low frequencies of the low expression allele of the MAOA-uVNTR and (marginally) S-form alleles of 5-HTTLPR; NEG was associated (marginally) with high proportions of A118 G-form and 5-HTTLPR S-form alleles in a given population; and RC was related to low frequency of A118 G-form, low expression MAOA-uVNTR alleles, and S-form alleles of 5-HTTLPR. Although these SNPs have effects on the development and functioning of very different neural mechanisms, each has been linked to risk for mood and anxiety disorders. Our findings suggest that temperament may be a mediating factor in the connection between allelic and psychological dysfunction frequency, as temperament contributes to the development of symptoms (e.g., Gartstein et al., 2012).

More generally, temperament and personality may be viewed as intermediary constructs linking the coevolution of genes and cultures. Although cross-cultural variability in individual differences has been largely framed in terms of the pathway of influence from culture to temperament/personality, the reverse effects are also possible, with the aggregate characteristics of the population, influenced in part by genetic composition, shaping the values and emphases of the culture. The gene-culture coevolutionary theory views cultural values as having evolved, both reflecting and influencing the environments (social and physical) under which genetic selection takes place (Boyd & Richerson, 1985). In this model, biologically distinct populations develop characteristic ways of behaving, which likely reflect reciprocal effects between allelic distributions and value systems, or the interplay between biology and culture. Genetic effects are, of course, subject to natural selection, wherein environmental pressures enhance the survival and reproductive fitness of those possessing genes that give rise to particular behavior patterns (i.e., temperament and personality) advantageous under certain conditions, but not others. Thus, cultural orientation dimensions likely contribute to the selection pressures operating upon behavioral individual differences within a given population, helping to determine the allelic frequency for related genes. Genetic effects, in turn, can be expected to shape cultural parameters, as genetic factors form the basis of individual differences in emotional responses, leading to differential consideration of threats/rewards related to most critical societal concerns (Chiao & Blizinsky, 2010; Way & Lieberman, 2010).

### 4.5. Limitations and future directions

Enthusiasm regarding the expansive scope of the current exercise, in which temperament was associated with geographic variability, global adult personality patterns, characteristics of cultures, and frequency of polymorphisms, is to some extent tempered by the limitations of our design. Most prominent is the number of cultures included. Whereas Big Five personality traits have been studied in over 50 cultures (e.g., McCrae et al., 2005a) and cultural orientation in more than 75 (e.g., Hofstede et al., 2010) nations, temperament data was available for only 18 countries. Because of incomplete overlap between temperament data and the archival data for other variables, some tests were conducted on very small sample sizes (e.g., 9 for the correlations between MAOA allele frequency and temperament) in our analyses, and concerns have been voiced regarding the accuracy of correlation coefficients calculated with small samples (e.g., Schönbrodt & Perugini, 2013). In addition, previous findings relating allelic prevalence to cultural orientation in samples similar to those used in the current study (i.e., Chiao & Blizinsky, 2010) failed to replicate when tested with a more global representation of countries (i.e., Minkov et al., 2015). Thus, our results should be viewed as preliminary, requiring replication with larger and more diverse samples before firm conclusions can be drawn.

Furthermore, the temperament samples used were combined across several ages, and several were reported in unpublished presentations, limiting our confidence in the comparability of the data obtained and the representativeness of the samples. Combining across ages also disallowed investigation of more fine-grained temperament attributes, which have been shown to be uniquely associated with psychological dysfunction (Gartstein et al., 2012). Also, because the psychometric properties of the questionnaires used at different ages are not identical, and thus may yield different effect sizes, combining them to a common metric could have introduced a degree of error into the aggregate scores. More generally, there are inherent limitations of aggregate-level data, in that they do not allow researchers to take into account variation of scores within cultures. Data collection efforts involving measurement of child temperament, adult personality, cultural orientation and/or SNPs in the same individuals would allow for more sophisticated analyses (e.g., multi-level modeling) concerning relations among these variables. An additional critique regarding the cross-cultural temperament research from which our data were obtained concerns failures to conduct tests of measurement invariance to determine whether the underlying meaning of items and the scales with which they are associated is consistent across groups. Although the individual instruments have been shown to achieve similar factor structures in different countries (e.g., Ahadi, Rothbart, & Ye, 1993; Montirosso et al., 2011), more extensive tests of invariance are warranted. Relatedly, culture has been implicated as a source of response bias. For instance, persons from East Asia tend to endorse fewer extreme responses during questionnaire completion than those from European cultures (Chen, Lee & Stevenson, 1995), which may have contributed to low scores on Surgency and Regulatory Capacity, and high scores on Negativity, among Asian countries in the current study.

Our investigation was limited in scope with respect to the other types of variables as well. At the cultural level, we did not take into account important economic indicators or psycho-social factors that may have qualified or complemented the impact of Hostede's dimensions. At the genetic level, we did not explore allelic distribution of other SNPs that have been identified as relevant to temperament. Expanding the analyses presented herein to other countries, more specific individual differences, and additional cultural and genetic variables, will prove useful for enhancing the lessons to be gleaned from the current effort.

The results of this investigation also require additional conceptual efforts and suggest directions for integrative empirical projects. Although the contextual-developmental model proposed by Chen (e.g., 2012; Chen, Chung, & Hsiao, 2008) and the developmental niche framework developed by Harkness and Super (e.g., 1994, Super & Harkness, 2002) are notable for their elegant integration of distal and proximal influences on developing individual differences, literature in these traditions has tended to focus on temperament constructs associated with negative emotions, with somewhat less attention paid to specific regulatory processes and almost no focus on positive approach tendencies. In addition, research in this vein has tended to emphasize collectivism-individualism without considering other cultural dimensions. Theory and data addressing the ways in which constructs such as Power Distance and Uncertainty Avoidance (Hofstede et al., 2010) are filtered through more proximal processes, such as relational vs. autonomous socialization goals of caregivers (Keller, 2007), to impact a wide range of temperament attributes should be considered, as such conceptual and empirical efforts are needed to arrive at a more comprehensive understanding of links between society and individual development.

Similarly, findings regarding differences between populations in proportion of psychologically-relevant alleles should be complemented by consideration of the neural and physiological processes through which genes impact behavior. In their recent review of the cultural neuroscience field, Chiao, Cheon, Pornpattananangkul, Mrazek, and Blizinsky (2013) provide an overview of research demonstrating relations between culture and neural bases of processes such as empathy, emotional response and social interaction, including neural processes previously explored in relation to temperament (e.g., amygdala responsivity; Kagan, 1994). Environmentally induced biological processes, such as fetal programming occurring as a result of prenatal exposure (e.g., to stress, nutrition) and as a function of epigenetic mechanisms (Babenko, Kovalchuk, & Metz, 2015), deserve closer consideration in this context, as these have been shown to extend across generations, similar to toxicant effects (Skinner, 2011; Skinner, Manikkam, & Guerrero-Bosagna, 2010), and are also likely to vary as a function of geographic region/cultural group.

In their summary of progress and promise in cultural neuroscience, Chiao et al. (2013) suggest that collaboration holds the key to further understanding the complex and dynamic elements of nature and nurture that shape individual differences. We enthusiastically agree. The internet has enabled unprecedented connection between scholars around the world, easing the creation of international teams to focus on common questions. These connections not only enhance coordination of data collection, they enable more thorough understanding of the meaning of socialization practices as viewed by members of different cultures. At the same time, increased appreciation of the importance of interdisciplinary perspectives is facilitating conversation and cooperation between psychologists and biologists, anthropologists and chemists, epidemiologists and economists. Building diverse teams around the globe and across academic disciplines will lead to a more enriched understanding of the development of temperament and personality.

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