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WELL-BEING AND PERSONALITY AS A FUNCTION OF GENETIC AND ENVIRONMENTAL INFLUENCES

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ABSTRACT

Subjective well-being (SWB) has been a growing focus of research internationally. Personality is one of the most important predictors of SWB. The interaction between SWB and personality is explained by a genetic component responsible for individual differences. Individual differences are a product of complex processes involving genetic and environmental factors, estimated through twin studies. The present study aims to estimate the genetic and environmental influences of SWB components and personality factors among pairs of twin siblings. A total of 201 pairs of twins, 146 MZ (monozygotic) and 55 DZ (dizygotic), with a mean age of 30.19 years (SD = 10.46, range 17 to 67 years), responded to the online questionnaire. We present estimates of heritability (h^2) and unique environmental effects (e^2) for SWB components: quality of life and life satisfaction (h^2 = 26% and e^2 = 74%), negative affect (h^2 = 23% and e^2 = 77%), and positive affect (h^2 = 21% and e^2 = 79%), and for personality factors: extraversion (h^2 = 55% and e^2 = 45%), conscientiousness (h^2 = 38% and e^2 = 62%), openness to experience (h^2 = 35% and e^2 = 65%), neuroticism (h^2 = 33% and e^2 = 67%), and agreeableness (h^2 = 23% and e^2 = 77%). This research has great potential, conducted in a country marked by social differences and population diversity, contributing to the understanding of factors that influence happiness and supporting interventions aimed at promoting mental health.

Keywords: Personality; Subjective well-being; Happiness; Individual differences; Heritability; Twins; Zygosity

BEM-ESTAR E PERSONALIDADE EM FUNÇÃO DE INFLUÊNCIAS GENÉTICAS E AMBIENTAIS

RESUMO

O bem-estar subjetivo (BES) tem sido um foco crescente de pesquisas internacionalmente. A personalidade é um dos mais importantes preditores de BES. A interação entre BES e personalidade é explicada por um componente genético responsável pelas diferenças individuais. As diferenças individuais são um produto de processos complexos envolvendo fatores genéticos e ambientais, estimados através de estudos com gêmeos. O presente estudo tem como objetivo estimar as influências genéticas e ambientais dos componentes do BES e dos fatores de personalidade entre pares de irmãos gêmeos. Responderam ao questionário online 201 pares de gêmeos, sendo 146 MZ e 55 DZ, com idade média de 30,19 anos (DP = 10,46, variação de 17 a 67 anos). Apresentamos estimativas de herdabilidade (h^2) e efeitos de ambiente único (e^2) para os componentes do bem-estar subjetivo: qualidade da vida e satisfação com a vida (h^2 = 26% e e^2 =

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74%), afetos negativos (h^2 = 23% e e^2 = 77%) e afetos positivos (h^2 = 21% e e^2 = 79%), e para os fatores da personalidade: extroversão (h^2 = 55% e e^2 = 45%), conscienciosidade (h^2 = 38% e e^2 = 62%), abertura à experiência (h^2 = 35% e e^2 = 65%), neuroticismo (h^2 = 33% e e^2 = 67%) e amabilidade (h^2 = 23% e e^2 = 77%). Esta pesquisa tem grande potencial, conduzida em um país marcado por diferenças sociais e diversidade populacional, contribuindo para a compreensão dos fatores que influenciam a felicidade e subsidiando intervenções que visem promoção de saúde mental.

Palavras-chave: Personalidade; Bem-estar subjetivo; Felicidade; Diferenças individuais; Herdabilidade; Gêmeos; Zigosidade.

BIENESTAR Y PERSONALIDAD EN FUNCIÓN DE INFLUENCIAS GENÉTICAS Y AMBIENTALES

RESUMEN

El bienestar subjetivo (BS) ha sido un enfoque creciente de investigación a nivel internacional. La personalidad es uno de los predictores más importantes del BS. La interacción entre el BS y la personalidad se explica por un componente genético responsable de las diferencias individuales. Las diferencias individuales son producto de procesos complejos que involucran factores genéticos y ambientales, estimados a través de estudios con gemelos. El presente estudio tiene como objetivo estimar las influencias genéticas y ambientales de los componentes del BS y los factores de personalidad entre pares de hermanos gemelos. Un total de 201 pares de gemelos, 146 MC (monocigóticos) y 55 DC (dicigóticos), con una edad promedio de 30,19 años (DE = 10,46, rango de 17 a 67 años), respondieron al cuestionario en línea. Presentamos estimaciones de heredabilidad (h^2) y efectos ambientales únicos (e^2) para los componentes del SWB: calidad de vida y satisfacción con la vida (h^2 = 26% y e^2 = 74%), afecto negativo (h^2 = 23% y e^2 = 77%), y afecto positivo (h^2 = 21% y e^2 = 79%), y para los factores de personalidad: extraversión (h^2 = 55% y e^2 = 45%), responsabilidad (h^2 = 38% y e^2 = 62%), apertura a la experiencia (h^2 = 35% y e^2 = 65%), neuroticismo (h^2 = 33% y e^2 = 67%), y amabilidad (h^2 = 23% y e^2 = 77%). Esta investigación tiene un gran potencial, realizada en un país marcado por diferencias sociales y diversidad poblacional, contribuyendo a la comprensión de los factores que influyen en la felicidad y apoyando intervenciones dirigidas a promover la salud mental.

Palabras clave: Personalidad; Bienestar subjetivo; Felicidad; Diferencias individuales; Heredabilidad; Gemelos; Zigosidad

1 INTRODUÇÃO

Subjective well-being (SWB) is a broad construct that comprises two components related to what people think (cognitive component) and feel (affective component) about their lives. The cognitive component concerns evaluations of the quality and satisfaction with one's own life. The affective component relates to positive and negative emotional responses to experiences (Diener et al., 2003; Diener et al., 1999; Giacomoni, 2004; Kim-Prieto et al., 2005; Pavot & Diener, 2008; Veenhoven, 2012). The study of happiness/subjective well-being (SWB) has been a growing focus of research internationally (Bartels, 2015) as understanding the factors that influence well-being

contributes to interventions aimed at prevention and promotion of mental health (Diener et al., 2009). Over 30 years of research, it has been observed that objective and external variables (e.g., health, income, marital status, age, gender, work, education) have little influence on SWB, so researchers have turned to the study of internal variables (e.g., personality, self-esteem, optimism) (Diener et al., 1999; Diener & Lucas, 1999; Diener et al., 2003).

Personality is one of the most important predictors of SWB (Diener et al., 1999; Diener & Lucas, 1999; Diener et al., 2003). It is a construct that represents individual patterns of thoughts, feelings, and behaviors, which are consistent and stable over time (Pervin & John, 2009). The Five Factor Model (FFM) understands personality in terms of traits (Extraversion, Neuroticism, Conscientiousness, Agreeableness, and Openness to Experience). These traits have a biological basis that interacts with the social and cultural environment and are at the core of the development of personal life narratives (McCrae et al., 2000).

According to the Dynamic Equilibrium Theory, changes and events in life have only short-term effects, and the level of SWB returns to a baseline that is determined in the long term by personality (Diener et al., 1999; Diener et al., 2003; Pavot & Diener, 2008). The interaction between SWB and personality is explained by a model that suggests a genetic component responsible for individual differences (Diener & Lucas, 1999; Diener et al., 2003; Shimmack, 2019; Weiss et al., 2008). Individual differences are a product of complex processes involving genetic factors (additive and non-additive effects) and environmental factors (shared and unique environment). Shared environmental influences refer to all non-genetic influences that make family members similar to each other. Unique environmental influences, also called non-shared, refer to independent influences for family members and include measurement errors. The parameter that estimates how much individual differences can be attributed to genetic factors in a specific population is called heritability (Knopik et al., 2016; Plomin et al., 2016). Studies with monozygotic (MZ) and dizygotic (DZ) twins have been conducted to assess genetic and environmental influences on a variety of psychological characteristics, such as personality and well-being. MZ twins have 100% genetic sharing, meaning they share all genes that vary in the population, while DZ twins have 50% genetic sharing, just like common biological siblings (Knopik et al., 2016).

Regarding personality, most twin studies suggest that 50% of the variance is associated with genetic influences, while the other 50% is associated with environmental effects (Segal, 1990; see also Goldsmith, 1983; Plomin & Daniels, 1987). According to Knopik et al. (2016), heritability varies between 30 and 50%. Vukasović and Bratko (2015) conducted a meta-analysis of heritability studies of personality and found that 40% of individual differences are due to genetic influences and 60% due to environmental influences. Of the 134 studies that participated in the meta-analysis, 10 adopted the FFM and included twin designs, showing heritability of 0.48 (0.45 - 0.51). Heritability was 0.36 (0.28 - 0.45) for extraversion, 0.37 (0.28 - 0.47) for neuroticism, 0.31 (0.22 - 0.40) for conscientiousness, 0.35 (0.28 - 0.42) for agreeableness, and 0.41 (0.31 - 0.51) for openness.

Regarding well-being, Bartels (2015) conducted a meta-analysis of heritability studies and found an estimate of heritability for overall well-being ranging from 17 to 56%. For well-being components, variations of 0 to 60% were found for life satisfaction, 22 to 41% for happiness, and 22 to 42% for quality of life. Of a total of 30 studies, 10 studies on overall well-being and 9 studies on life satisfaction were included in the meta-analysis. The results estimated heritabilities of 36% (34-38) for overall well-being and 32% (29-35) for life satisfaction.

However, these twin studies on the heritability of personality and well-being have been conducted with populations from developed countries. It is known that heritability is related to inequality, with higher societal inequality associated with lower heritability due to greater environmental variation (Knopik et al., 2016; Plomin et al., 2016; Turkheimer et al., 2003; Turkheimer et al., 2011). There are few or no studies with twins on the heritability of psychological measures in developing countries, or non-WEIRD (i.e., non-Western, educated, industrialized, rich, and democratic), like Brazil. Brazil, being a vast and populous, culturally, ethnically, and economically diverse country (Bosi, 1992; IBGE, 2011; IBGE, 2017), may contribute to investigating the relationship between environmental context and heritability.

Polderman et al. (2015) meta-analysis showed that only 0.5% of studies were located in South America. Of the 2,748 studies that were part of the meta-analysis, only 10 were Brazilian, compared to 947 in the USA, 377 in the UK, and 259 in Australia. Of these 10 Brazilian studies, none were in the field of Psychology. In order to better understand the underrepresentation of Brazilian twin studies in the international scene, de Souza Fernandes et al. (2024) conducted a scoping review. Of the 340 studies found, almost half were in the field of Medicine (N = 161), followed by Psychology (N = 47), Dentistry (N = 36), and Biology (N = 29). In addition, no research on subjective well-being was found, and of the personality research, none sought to investigate individual differences, being studies with small samples and other approaches.

Additionally, another factor highlighting that Brazil has enormous potential for twin studies is that the birth of twins in Brazil is increasing, and consequently, there is an increasing demand for information about this population. In Brazil, the birth of twins increased by 30.8%, as studies analyzing birth rates over ten years in the city of São Paulo (Otta et al., 2016) and in the country showed, with the average twin birth rate being 9.39‰ (Cardoso-dos-Santos et al., 2018; Varella et al., 2018).

The present study aims to estimate the genetic and environmental influences of the five personality traits (extraversion, neuroticism, conscientiousness, agreeableness, and openness to experience) and indicators of subjective well-being (quality of life, positive and negative affects, and life satisfaction), comparing pairs of MZ and DZ twin siblings. This is a pioneering study with Brazilian twins from a psychological and behavioral perspective, as well as investigating heritability in a country marked by social differences and population diversity. The well-being research field is recent and there are very few twin studies in the country. Worldwide, SWB has been studied as one of the

ways to access the quality of life of societies, along with economic and social indicators (Diener et al., 2003). In addition to its theoretical interest, it has practical interest, contributing to support interventions aimed at promoting mental health and increasing quality of life (e.g., Haworth et al., 2016).

This research is part of the master's dissertation "Subjective well-being and personality: a study with twin siblings" (Fernandes, 2021), developed in the Graduate Program in Experimental Psychology at the Instituto de Psicologia of the Universidade de São Paulo. It is also linked to the Painel USP de Gêmeos, which started its activities in 2015 and was formally founded in 2017, under the coordination of Prof. Dr. Emma Otta and based at the Instituto de Psicologia of the Universidade de São Paulo. The Painel USP de Gêmeos aims to conduct research on behavior and basic psychological processes, maintaining a registry of twins, with nearly 7000 registered (Fernandes, 2021; Otta et al., 2019).

2 MATERIAL AND METHODS

Participants

A total of 1148 individuals responded to the survey, of which 330 were complete pairs. Meeting the inclusion criteria, we had 201 pairs of twins, with 149 (74.1%) females (FF), 36 (17.9%) males (MM), and 16 (8.0%) opposite sex (FM), with a mean age of 30.19 years (SD = 10.46, range 17 to 67 years). The average age for MZ twins was 31.55 years (SD = 11.03) and for DZ twins was 26.60 years (SD = 7.74). According to the zygosity classification by Christiansen et al. (2003), 146 (72.6%) were MZ (118 FF and 28 MM) and 55 (27.4%) were DZ (31 FF, 8 MM, and 16 FM). We had information on the place of residence of 86.1% of the sample, of which 75.6% lived in the southeast region. The inclusion criteria were: 1. twin siblings, 2. reared together, 3. over 18 years old, 4. both siblings of a pair responded to the survey (i.e., complete pairs).

Instruments

Identification and sociodemographic data: Participants were asked for their email and CPF or pair identification code, as well as the respondent's sex, sibling's sex, date of birth, whether the siblings were reared together or apart, and self-classification of zygosity in the case of twins.

Zygosity Questionnaire: The instrument by Christiansen et al. (2003) consists of two questions about physical resemblance (one about how similar the siblings are and another about whether both had the same eye and hair color in childhood) and two about differentiation difficulty

(one about confusions in school by teachers and classmates, and another by family and friends). This questionnaire has been used by the Danish Twin Registry for over half a century and, in addition to being short, has been validated with genotyping in Brazil, showing 96.6% accuracy (Fernandes, 2021; Varella, in press).

Personality Questionnaire: The Reduced Inventory of the Big Five Personality Factors (IGFP-5R) is based on the Spanish version of the Big Five Inventory (BFI), adapted and validated for the Brazilian population (Andrade, 2008; Laros et al., 2018). Five factors (Extraversion, Neuroticism, Conscientiousness, Agreeableness, Openness to Experience) are assessed based on 16 items, rated on a 7-point scale ranging from "strongly disagree" to "strongly agree."

Life Satisfaction Questionnaire: The Satisfaction with Life Scale (SWLS) is a brief overall assessment of an individual's satisfaction with their life as a whole (Diener et al., 1985), consisting of 5 statements to be rated on a 7-point scale ranging from "totally disagree" to "totally agree." The life satisfaction score is the average of the 5 scale items. This is the version available in Portuguese on Professor Ed Diener's website (http://labs.psychology.illinois.edu/~ediener/SWLS.html).

Emotional Well-being Questionnaire: This instrument consists of 10 items, half about positive feelings (e.g., "pleasure," "joy," "did you smile or laugh a lot yesterday?") and half about negative feelings (e.g., "worry," "sadness"), to be answered about the previous day with "yes" or "no" (Kahneman & Deaton, 2010). The positive affect score is the average of the 5 items on positive feelings, and the negative affect score is the average of the 5 items on negative feelings. This is a version translated and adapted by us for the purpose of this research.

Cantril Scale: Cantril's Self-Anchoring Scale consists of only one item to assess life as a whole, through the rung of the ladder where the respondent stands in terms of satisfaction, with 10 being the best possible life and 0 being the worst possible life (Kahneman & Deaton, 2010; Cantril, 1965). This is a version translated and adapted by us for the purpose of this research.

Procedure

Data collection was conducted online through the Google Forms Platform. The research was disseminated through the Painel USP de Gêmeos and social networks. The Painel USP de Gêmeos registration was advertised on Facebook, Instagram, and the Painel USP de Gêmeos website, as well as on the Instituto de Psicologia of USP website and by email to all employees, students, and professors of the USP community, through the Superintendence of Information Technology (STI). Twins who filled out the registration form received an invitation to participate in the survey by email, which included, in addition to the survey link, a code for identifying the pair to

which the individual belonged. For more information on the Painel USP de Gêmeos, see Otta et al. (2019) (also see Fernandes, 2021).

Efforts were made for both siblings to respond to the survey. When we had contact information for both siblings of the pair, we contacted the one who did not respond. In cases where only one sibling's contact was available, we contacted that sibling and requested the sibling's email or that they forwarded the survey link and code.

In the form, after completing the Informed Consent Form, participants responded to the instruments in the order presented above.

The research was approved by the Research Ethics Committee with Human Beings of the Instituto de Psicologia, Universidade de São Paulo, Brazil (Protocol Number: 1,298,750).

Analyses

After checking zygosity from the questionnaire and computing the average scores of each well-being and personality instrument, we performed descriptive analyses of the sample. We followed the instructions from the online course "Twins Statistical Analysis eModules" from the Australian Twin Registry to estimate the genetic and environmental influences on well-being and personality. We adjusted a mixed model that allows calculating separate effects for MZ and DZ pairs, with adjustment for participant sex. With the covariance values, we calculated intraclass correlations (ICC). ICC values indicate reliability: poor for values less than 0.4, fair between 0.4 and 0.59, good between 0.6 and 0.74, and excellent for values between 0.75 and 1 (Cicchetti, 1994). The correlations of MZs and DZs allow inferring the genetic and environmental influences involved (Table 1).

Table 1. Comparisons between MZ and DZ correlations for inference of genetic and environmental influences

rMZ = 2 x rDZ	Additive genetic effects
rMZ = rDZ > 0	No genetic effect, effect of family environment
rMZ = rDZ = 0	No genetic or family environment effect
2 x rDZ > rMZ > rDZ	Additive genetic and shared environmental effects
rMZ > 2 x rDZ	Genetic dominance or epistasis (gene interactions)

Source: Translated and adapted from the online course "Twins Statistical Analysis eModules" from the Australian Twin Registry.

Secondly, we analyzed how much of the total variance in well-being and personality was due to genetic additive effects (A), shared environmental effects (C), and non-shared environmental effects (E). Again, with the covariance values, we calculated the variance components and then the proportion of variance due to A, C, and E. For cases where the proportion of C variance was very small and outside the possible limits of the confidence interval, we adjusted a model with only A and E.

For the analyses, Microsoft Excel 2016, Stata 13, and the Statistical Package for Social Science (SPSS 26) were used.

3 RESULTS

Well-being

After adjusting for gender, the correlations of MZs were greater than those of DZs for all well-being indicators. The ICC value for all indicators was low, indicating poor reliability. The coefficients for MZs and DZs were not significant, except for life satisfaction. For life satisfaction, the correlation of MZs was 1 to 2 times greater than that of DZs, suggesting additive genetic and shared environmental effects.

Table 2. Intra-class correlation coefficients (ICC) in MZ and DZ pairs, heritability, and unique environmental effect for well-being indicators.

Measure	ICC MZ	95% CI	ICC DZ	95% CI	h^2	95% CI	e^2	95% CI
Quality of lfe	0.26 (0.08)	0.10-0.43	0.11 (0.13)	-0.14-0.36	0.26 (0.08)	0.10-0.43	**0.74 (0.08)**	0.57-0.90
Positive affect	0.21 (0.08)	0.06-0.37	0.00	-	0.21 (0.08)	0.06-0.37	**0.79 (0.08)**	0.63-0.94
Negative affect	0.23 (0.08)	0.07-0.39	0.03 (0.13)	-0.22-0.28	0.23 (0.08)	0.07-0.39	**0.77 (0.08)**	0.61-0.93
Life satisfaction	**0.26 (0.08)**	0.10-0.42	0.15 (0.13)	-0.09-0.40	**0.26 (0.08)**	0.10-0.42	**0.74 (0.08)**	0.58-0.90

Note. MZ = Monozygotic twins, DZ = Dizygotic twins, ICC = Intra-class correlation coefficient, CI = 95% Confidence Interval, h^2 = Heritability (additive genetic effects - A), e^2 = Unique environmental effects. N MZ =

146 and N DZ = 56. Cells in bold indicate significant values (p <0.001). Standard deviation values are in parentheses.

Since the model works well for correlations between 0.3 and 0.7 and, in cases of very low correlations, outside the possible confidence interval limits, we found the proportion of variance C to be almost negligible or negative. Thus, the most suitable model for estimating the proportion of genetic and environmental effects considered only additive genetic (A) and non-shared environmental effects (E). For all well-being indicators, the unique environmental effect (e^2) was greater than heritability (h^2), approximately 70% for e^2 and 20% for h^2. For life satisfaction, heritability was 26% and the unique environmental effect was 74%.

Personality

After adjusting for gender, the correlations of MZs were greater than those of DZs for all personality factors except conscientiousness, which was equal. The ICC value for extraversion was high, indicating reasonable reliability, while the others were lower, indicating poor reliability. The coefficients for MZs were significant for all personality factors except for agreeableness, while the coefficients for DZs were not significant except for conscientiousness.

Table 3. Intra-class correlation coefficients (ICC) in MZ and DZ pairs, heritability, and unique environmental effect for personality factors.

Measure	ICC MZ	95% CI	ICC DZ	95% CI	h^2	95% CI	e^2	95% CI
Extraversion	**0.55 (0.06)**	0.44-0.66	0.31 (0.14)	0.04-0.58	**0.55 (0.06)**	0.44-0.66	**0.45 (0.06)**	0.34-0.56
Neuroticism	**0.33 (0.08)**	0.18-0.48	0.28 (0.12)	0.05-0.52	**0.33 (0.08)**	0.18-0.48	**0.67 (0.08)**	0.52-0.82
Conscientiousness	**0.39 (0.06)**	0.27-0.51	**0.39 (0.06)**	0.27-0.51	**0.38 (0.07)**	0.25-0.52	**0.62 (0.07)**	0.48-0.75
Agreeableness	0.22 (0.09)	0.05-0.40	0.12 (0.14)	-0.15-0.39	0.23 (0.09)	0.05-0.40	**0.77 (0.09)**	0.60-0.95
Openness to experience	**0.35 (0.07)**	0.21-0.49	0.11 (0.15)	-0.19-0.40	**0.35 (0.07)**	0.21-0.49	**0.65 (0.07)**	0.51-0.79

Note. MZ = Monozygotic twins, DZ = Dizygotic twins, ICC = Intra-class correlation coefficient, CI = 95% Confidence Interval, h^2 = Heritability (additive genetic effects - A), e^2 = Unique environmental effects. N MZ =

146 and N DZ = 56. Cells in bold indicate significant values (p <0.001). Standard deviation values are in parentheses.

The correlations of MZs were about two times greater than those of DZs for extraversion and neuroticism, suggesting genetic dominance or epistasis (gene interactions). For openness, the correlation of MZs was between 1 to 2 times greater than that of DZs, suggesting additive genetic and shared environmental effects. For conscientiousness, the correlations of MZs and DZs were equal and greater than zero, suggesting a familial environmental effect and the absence of a genetic effect.

The most suitable model for estimating the proportion of genetic and environmental effects considered only additive genetic (A) and non-shared environmental effects (E). For extraversion, heritability (h^2) was greater than the unique environmental effect (e^2), with 55% for h^2 and 45% for e^2. For the other personality factors, the unique environmental effect was greater than heritability, with approximately 60-70% for e^2 and 20-30% for h^2.

4 DISCUSSION

The present study aimed to investigate the heritability of well-being and personality, marking the first study with Brazilian twins on the heritability of psychological measures. We provide estimates for subjective well-being components: quality of life and life satisfaction (h^2 = 26% and e^2 = 74%), negative affect (h^2 = 23% and e^2 = 77%), and positive affect (h^2 = 21% and e^2 = 79%), as well as for personality factors: extraversion (h^2 = 55% and e^2 = 45%), conscientiousness (h^2 = 38% and e^2 = 62%), openness to experience (h^2 = 35% and e^2 = 65%), neuroticism (h^2 = 33% and e^2 = 67%), and agreeableness (h^2 = 23% and e^2 = 77%).

Overall, our results slightly differ from findings in the literature, as we found lower heritability estimates and higher unique environmental effects. For life satisfaction and quality of life, we found heritability of 26% and unique environment of 74%, slightly different from findings in Vietnam (h^2 = 19% and e^2 = 79% in male pairs; Franz et al., 2012), the Netherlands (h^2 = 34% and e^2 = 66% in male pairs, and h^2 = 47% and e^2 = 53% in female pairs; Bartels et al., 2013), and Bartels' meta-analysis (2015) (h^2 = 32% for life satisfaction).

Of note, the heritability and unique environmental estimates for quality of life and life satisfaction are similar (h^2 = 26% and e^2 = 74%), supporting Bartels and Boomsma's (2009) findings that life satisfaction, happiness, and quality of life measure the same genetic construction.

Regarding personality, our results differ from international literature findings for neuroticism (h^2 = 33% and e^2 = 67% vs. Canada: h^2 = 41% and e^2 = 59% (Jang et al., 1996); USA: h^2 = 58% and e^2 = 42% (Loehlin et al., 1998); and Germany: h^2 = 52% and e^2 = 48% (Riemann et al., 1997)),

conscientiousness (h^2 = 38% and e^2 = 62% vs. Canada: h^2 = 44% and e^2 = 56% (Jang et al., 1996); USA: h^2 = 52% and e^2 = 48% (Loehlin et al., 1998); and Germany: h^2 = 53% and e^2 = 47% (Riemann et al., 1997)), agreeableness (h^2 = 23% and e^2 = 77% vs. Canada: h^2 = 41% and e^2 = 59% (Jang et al., 1996); USA: h^2 = 51% and e^2 = 49% (Loehlin et al., 1998); and Germany: h^2 = 42% and e^2 = 58% (Riemann et al., 1997)), and openness to experience (h^2 = 35% and e^2 = 65% vs. USA: h^2 = 56% and e^2 = 44% (Loehlin et al., 1998); and Germany: h^2 = 53% and e^2 = 47% (Riemann et al., 1997)).

However, our extraversion results are similar to international literature findings (h^2 = 55% and e^2 = 45% vs. Canada: h^2 = 53% and e^2 = 47% (Jang et al., 1996); USA: h^2 = 57% and e^2 = 44% (Loehlin et al., 1998); and Germany: h^2 = 56% and e^2 = 44% (Riemann et al., 1997)). These studies, used for comparison, adopt the FFM and were part of Vukasović and Bratko's (2015) meta-analysis.

Our heritability estimates are more similar to Vukasović and Bratko's (2015) meta-analysis: neuroticism (33% vs. 37%), conscientiousness (38% vs. 31%), openness to experience (35% vs. 41%), agreeableness (23% vs. 35%), and extraversion (55% vs. 36%). They are also similar to South et al.'s (2018) findings in the USA: neuroticism (33% vs. 34%), conscientiousness (38% vs. 36%), openness to experience (35% vs. 27%), agreeableness (23% vs. 31%), and extraversion (55% vs. 33%). The unique environmental results, except for extraversion, are more similar to Weiss, Bates, and Luciano's (2008) study, also in the USA, which, like our study, investigated personality traits and life satisfaction in twins: neuroticism (67% vs. 73%), conscientiousness (62% vs. 69%), agreeableness (77% vs. 75%), openness to experience (65% vs. 64%), and life satisfaction (74% vs. 84%). Røysamb et al. (2018) also found heritabilities in Norway more similar to ours for life satisfaction (26% vs. 32%), extraversion (55% vs. 49%), and neuroticism (33% vs. 53%).

Overall, the heritability of subjective well-being components (≅ 20-30%) is lower than that of personality factors (≅ 20-60%). These results, slightly lower than those in the literature, corroborate findings, as personality heritability varies between 30 and 50%, according to Knopik et al. (2016), and well-being heritability varies between 29 and 35%, for life satisfaction, according to Bartels (2015). In Fernandes et al.'s case study (in preparation) on a pair of Brazilian twins who grew up apart and reunited in adulthood, the twins were also less similar for life satisfaction and more similar in personality traits.

This study collected personality and well-being data from nearly 1200 twins over a little more than three years, of which 201 are twin pairs (146 MZ and 55 DZ). For a recent twin registry like the Painel USP de Gêmeos, this is a good result, compared to international studies, whose registries have existed for decades and samples vary between 300 and 900 pairs. Our research contributes to the field as it was conducted with a non-WEIRD sample, constituting a pioneering study on well-being and personality heritability in our country. Furthermore, it is the first study on the topic in Brazil since, as data from de Souza Fernandes et al. (2024) show, out of 340 studies with Brazilian twins, only 47 are in the psychology field. Of these 47, none address subjective well-being, with only 14 addressing personality. Our study presents a considerable sample, promising results, and is one of

the studies from the Painel USP de Gêmeos that has promoted psychological studies with twins in Brazil.

The slightly lower heritability estimates and slightly lower unique environmental effects make us wonder if the differences in results are due to this study being conducted in a developing country, besides being vast, populous, culturally, ethnically, and economically diverse (Bosi, 1992; IBGE, 2011; IBGE, 2017), compared to the mentioned international literature studies conducted in developed or WEIRD (Western, Educated, Industrialized, Rich, and Democratic) countries. However, despite being conducted with a Brazilian sample, this study is not representative of the country's diversity, as most participants lived in SP and were university students, explained by the widespread dissemination of the research and the Painel USP de Gêmeos throughout the USP community and via social networks. A limitation of our study was not collecting information on participants' income and education, necessary data to study heritability in situations of inequality. Additionally, considering results consistent with meta-analyses and recent publications, we also suggest that there may be a temporal difference in samples, as classical studies are from past decades, requiring investigation of other factors involved.

Another limitation of this study was the unbalanced sample, as few DZ twins and few men participated, a common sampling bias in twin studies (Lykken et al., 1987). The sample was also unbalanced in terms of age. Additionally, we collected responses from non-twin siblings (N = 31), data that we did not include in the analyses. Preliminary analyses including non-twin pairs show higher intra-class correlations for MZs compared to DZs and, in turn, NGs (MZ > DZ > NG). This greater similarity is associated with MZs having 100% genetic sharing, while DZs and NGs have 50% (Knopik et al., 2016; Ridley, 2003: Segal, 1990).

We emphasize the importance of adopting sophisticated analysis models for the data by adjusting for participants' sociodemographic characteristics (e.g., sex). While MZs and DZs correlation values allow inference of genetic and environmental influences involved in well-being and personality, we observed different results from those inferred by correlations when calculating the proportions of variances relative to genetic effects, shared environments, and unique environments. Nonetheless, this is a method with limitations, as the proportion of variance of C was very small and outside the possible confidence interval limits, requiring us to adjust our model to estimate only genetic and unique environmental influences. Since this model presents problems with Wald confidence intervals for variance proportions, it may be necessary to use more specialized software for these analyses (e.g., Solar, Fisher, OpenMx).

In studies on heritability, it is important to note that this is a concept about nature and nurture. Heritability is often understood as a topic restricted to genetics without considering the complexity of this concept, highly dependent on context. The effect of the environment on the phenotype depends on genetics, and the effect of genetics on the phenotype depends on the environment. Thus,

estimating the genetic influences of behavior is just an important first step in understanding the origins of individual differences (Knopik et al., 2016).

In our research, the model with the best fit included estimates of heritability and unique environment. We were struck by the low values relative to the shared environment. Several studies, including Tellegen et al. (1988), suggest the same direction, where the family environment has a low effect, while the main factors involved in the constitution and variation of psychological characteristics are genetic and non-shared environmental factors.

Future studies investigating the heritability of behavioral and psychological traits in samples with different income and education levels are suggested. Additionally, longitudinal studies on personality and well-being may contribute to understanding these two characteristics, so stable and related (e.g., Lykken & Tellegen, 1996). Also, studies collecting well-being and personality data in the same sample could provide information to deepen understanding of the relationship between these two constructs and the underlying mechanisms (Shimmack, 2019; Weiss et al., 2008). Finally, it may be interesting to compare concordant and discordant twins regarding their self-perception of zygosity and their classification by DNA or questionnaires highly correlated with DNA. For example, DZ twins who grew up thinking they were MZ are more similar in personality than DZ twins who grew up thinking they were DZ? And MZ twins who grew up thinking they were DZ are more different in personality than twins who grew up thinking they were MZ?

This is a pioneering study on well-being and personality heritability in Brazil. We hope the results inspire other studies with Brazilian twins, which are discussed with internationally found heritability results, and which help support interventions and policies aimed at promoting mental health and quality of life.

5 CLOSING REMARKS

The present study investigated the heritability of subjective well-being and personality in adult Brazilian twins. The results found lower heritability estimates (≅ 20-30%) and higher unique environmental effects (≅ 60-70%) compared to the heritabilities (≅ 30-60%) and unique environmental effects (≅ 40-60%) found in twin studies conducted internationally (well-being: Bartels et al., 2013; Franz et al., 2012; personality: Jang et al., 1996; Loehlin et al., 1998; Riemann et al., 1997). Extraversion was an exception. However, the results are similar to the literature when compared to those presented in meta-analyses (well-being: Bartels, 2015; personality: Vukasović & Bratko, 2015) and other more recent studies (Røysamb et al., 2018; South et al., 2018; Weiss et al., 2008).

In this study, due to the limitation of not collecting income and education data, it was not possible to confirm that the lower heritabilities are explained by the sample being non-WEIRD. By

corroborating the results of meta-analyses and recent publications, we also suggest that there may be a temporal difference in samples, as classical studies are from past decades, requiring investigation of other factors involved. Nonetheless, our results contribute to the field, which lacks information from populations in developing countries.

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In conclusion, we see great potential in this pioneering research on well-being and personality in Brazilian twins. Understanding which factors influence happiness can support interventions aimed at promoting mental health. Furthermore, we can better understand human nature and uniqueness. We agree with Thomas Bouchard: "Twin studies refute both biological and environmental determinism. They do not negate the effect of the environment on behavior, nor do they over glorify the role of genes. They account for the uniqueness of each of us (Segal, 2017, p. 14)."

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