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Behavioral genetics of temporal framing: Heritability of time perspective and its common genetic bases with major personality traits

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Abstract

Objective: The present study aimed to provide a seminal behavioral genetic analysis of time perspectives (TPs). Moreover, we intended to investigate the magnitude of genetic vs. environmental components of the well-established assocations between TPs and personality features.

Background: Individual differences in temporal framing processes, referred to as TPs, are vital psychological and behavioral outcomes. Although proponents of TP theory emphasize mainly environmental origins of the tendencies to adopt certain TPs, research provides evidence for marked associations between the temporal dimensions and major personality traits that are known to be heritable. Hence, it was essential to empirically verify these claims.

Method: The article reports an analysis of genetic and environmental components of variance in TPs based on a study adopting a twin design, conducted on a sample of 393 pairs of twins (135 monozygotic and 258 dizygotic).

Results: Multivariate Cholesky decomposition supported an EA model assuming impacts of both unshared environmental factors (E) and additive genetic factors (A) across all TP dimensions, suggesting that the effects of shared environment on TPs are plausibly negligible. Heritability indices of TPs ranged between 0.51 for Present-Fatalistic and 0.62 for Present-Hedonistic, suggesting that the majority of the variance in TPs stems from genetic influences. Substantial genetic correlations were found between TPs and the Big Five personality traits.

Conclusions: The findings provide further evidence for conceptualizing TPs as biologically based personality traits and challenge the claims that TP is mainly a product of culture, education, and personal experiences.

KEYWORDS
environment, genes, heritability, time perspective, twin studies, ZTPI

1 | INTRODUCTION

According to the first law of behavioral genetics, “all human behavioral traits are heritable” (Turkheimer, 2000, p. 160). The claim seems obvious with respect to temperamental traits and cognitive abilities which at least partly emerge from individual differences in features of neurobiological systems (e.g., Duncan et al., 2000; Trofimova & Robbins, 2016). However, in the case of more complex personal characteristics distinguished within less biologically oriented conceptual approaches, the pronounced role of genetic factors in shaping personality features and behavioral tendencies still remains neglected. Given the overwhelming evidence from numerous studies for marked heredity of practically all personality features (Vukasović & Bratko, 2015), it is anticipated that higher order traits will also be substantially inherited. Time perspective (TP) theory (Zimbardo & Boyd, 1999, 2008) remains an example of a theory that on the one hand (though plausibly somewhat inadvertently) operates within the methodology typical for individual differences research, but on the other hand, explains human cognitive and behavioral tendencies focusing almost solely on cultural, educational, and environmental factors (see Zimbardo & Boyd, 2008). Such an approach seems incoherent not only with the said law of behavioral genetics, but also with results of both cross-sectional (see a meta-analysis by Kairys & Liniauskaite, 2015) and longitudinal (Stolarski et al., 2021) studies, providing vital evidence for marked associations of TP dimensions with personality and temperamental traits characterized by well-proven, essential genetic bases (e.g., Riemann et al., 1997; Takahashi et al., 2007). In the present paper, we challenge Zimbardo and Boyd's (2008) claims on environmental causation by providing a pioneering behavioral genetic analysis of the origins of individual differences in TP. Moreover, we provide a seminal insight into genetic vs. environmental sources of the pronounced overlap between TP dimensions and the Big Five personality traits.

1.1 | Time perspective

Human beings have the unique capacity to transcend the here and now and perform mental time travels back to the past and forward into the future (Suddendorf & Corballis, 2007). People continuously and mostly unconsciously allocate their mental resources to the past (as kept in their memories), the present (i.e., the ongoing current events), or the future (represented in their plans, goals, and possible selves) (see Zimbardo & Boyd, 1999). Stolarski et al. (2018) referred to this transient, situational focus on one or another of the temporal horizons as state-TP. Nonetheless, individuals differ in their habitual or "default" tendencies to focus on vs. neglect different time horizons. They also tend to manifest specific attitudes toward each of them. These relatively stable features have been labeled trait-TPs (Stolarski et al., 2018). Zimbardo and Boyd (1999) distinguished five basic temporal dimensions. Their model was further revised by Carelli et al. (2011). In the present paper, we follow the latter conceptualization, comprising six TPs: Past-Negative (depicting a tendency to relive past traumas and experience ruminating, aversive past memories), Past-Positive (reflecting a warm, sentimental view of the past, sense of nostalgia and fondness for the good, old days), Present-Hedonistic (focus on immediate pleasures accompanied with impulsivity, propensity to risk, and seeking sensations and novelty), Present-Fatalistic (reflected in external locus of control and helplessness), Future-Positive (depicting focus on personal goals and consideration of future consequences of current actions, accompanied by a general tendency for optimistic future thinking), and Future-Negative (reflected in concentration on threats and future anxiety). Moreover, people may switch their focus between particular time horizons more or less effectively. High capacity to flexibly shift between TPs in response to changing situational demands was labeled ***balanced TP*** (BTP; Zimbardo & Boyd, 1999). A balanced temporal profile provides the necessary basis for effective and flexible temporal switching (Zimbardo & Boyd, 2008), and predicts a variety of indicators of social effectiveness and mental well-being (see Stolarski et al., 2020, for a review).

As one of the most renowned proponents of the situationist approach in explaining human behavior, Zimbardo used to define TP as the "often non-conscious process whereby the continual flows of personal and social experiences are assigned to temporal categories" (Zimbardo & Boyd, 1999, p. 1271). However, probably due to the elusiveness of such a dynamic, processual framing of TP and a lack of a reasonable alternative to study such a complex cognitive-emotional phenomenon, since the very beginning he endorsed a self-report metric of individual differences in TPs (Zimbardo & Boyd, 1999). This discrepancy between the definition and its operationalization was to some degree reduced in more recent works on TPs (Stolarski et al., 2018). Nevertheless, TPs remained to be treated as originating entirely from personal experiences gathered within familial, social, and cultural contexts (as originally proposed by Zimbardo & Boyd, 2008). Zimbardo and Boyd claim that we are *all* born present-hedonists, and we *may* become future-oriented. They even explicitly state that "no one is born with a future time perspective. No gene pushes people into a future time zone. You become future-oriented by being born in the right place, at the right time, where environmental conditions help transform little present-oriented babies into restrained, successful, future-oriented adults" (Zimbardo & Boyd, 2008, p. 137). Among the environmental factors responsible for the development of future TP they list education, living in a stable family, having future-oriented role models, religion (i.e., being Protestant or Jewish), and having regular access to technology.

A few studies seem to provide support for the role of family environment in shaping individual differences in TPs (e.g., demonstrating their associations with attachment patterns; Laghi et al., 2008; or childhood adversities; Styła et al., 2019). However, the entire nomological network of

TPs, including robust correlations with strongly heritable temperaments (see Appendix A in Stolarski et al., 2015), as well as associations with purely biological features, such as gray matter volume in the ventral precuneus (Guo et al., 2017) and allostatic load (Bourdon et al., 2020), suggest that denying the role of innate, genetic influences in TP development may be simply a result of situationist bias in explaining human behavior. Some marked overlaps between TPs and the Big Five personality traits, including the 0.48 meta-analytical correlation between Past-Negative and neuroticism and 0.60 between Future and conscientiousness (Kairys & Liniauskaite, 2015) even exceed the environmentally shaped portion of variance in these Big Five traits (cf. Riemann et al., 1997). The question of whether phenotypic correlations between TPs and the Big Five reflect shared genetic and/or shared environmental influences can be addressed using multivariate modeling methods (Neale & Cardon, 1992). Personality studies have shown common genetic influences on major traits and a diversity of other factors ranging from clinical constructs such as borderline personality disorder (Distel et al., 2009) to socio-political attitudes (De Vries et al., 2022). However, modeling phenotypic correlations may also generate complex models that include multiple genetic and environmental factors (e.g., Kendler et al., 2019), and, to date, there have been no studies that have decomposed TP—Big Five correlations.

Zimbardo and Boyd (2008) also neglect some known features of genetic influences on traits (e.g., Plomin et al., 2016). Genetic influences vary over the course of brain maturation, so the present orientation of infants says nothing about the heritability of future orientation, which may depend on later-developing brain systems. Zimbardo and Boyd's (2008) analysis also seems to ignore the interactions of genes and environment during development. Environmental factors are themselves partially heritable (Kendler & Baker, 2007), reflecting processes such as genetic influences on environmental niche-seeking (Penke & Jokela, 2016). For example, children with a genotype that promotes Future-Positive may actively seek out environments that reward and value delayed gratification and planning for the future.

The role of gene–environment interaction is also highlighted in Kruger's (2021) Evolutionary Life History Theory (LHT) which proposes that the organism's strategies for allocating resources are shaped by environmental pressures, including the predictability of future events. When the environment is unstable and unpredictable, organisms tend to allocate resources to risk-taking and prolific mating, with little long-term investment in stable relationships and care for offspring (Dunkel & Kruger, 2015; Kruger et al., 2008). In contrast, predictable environments encourage long-term personal commitments to partners and children. Although LHT was originally formulated as a population-level theory, it may also be applicable to individual differences in time perspective (Dunkel & Kruger, 2015). Interaction of the genotype with childhood environmental factors may shape the individual's preference for short-term vs. long-term adaptive strategies.

1.2 | The present study

Given that TP features have not been a subject of behavioral genetic research, our study aimed to provide pioneering insight into the composition of factors contributing to individual differences in TPs by disentangling the relative effects of genetic and environmental factors. The study applied twin studies methodology which stems from the fact that both monozygotic (MZ) and dizygotic (DZ) twins share 100% of their common environment; however, the former share 100% of their genes, while the latter—only 50% (just like ordinary siblings).

Using the classic behavioral genetic approach, based on the comparisons of correlations in samples of monozygotic and dizygotic twins, we may therefore obtain estimates of the genetic factor (typically referred to as heritability), common (shared) environment, and unique (specific) environment. Given the numerous weaknesses of the classical approach, currently, more sophisticated and more accurate analytical methods became standard in approaching twin data. The latter methods (further discussed later in the paper) were also applied in the present analyses. The study aimed to investigate the following issues.

1.2.1 | Heritability of TP dimensions

Zimbardo and Boyd's (2008) situational perspective of TP implies that heritability of ZTPI dimensions will be close to zero. They especially singled out future perspectives as being entirely environmental in origin. By contrast, the ubiquity of genetic influences on personality and other human traits (Polderman et al., 2015; Vukasović & Bratko, 2015) implies heritability in the 0.4–0.5 range seen in the meta-analyses just cited. The temperamental loadings of TP dimensions cited above (Stolarski et al., 2021) also imply heritability. Besides analyzing the contribution of nature vs. nurture to individual differences in TP, we also aimed to resolve whether the six ZTPI dimensions differ in the magnitude of the genetic component. TPs markedly differ in the amount of variance explained by (by definition biologically based) temperamental factors (Stolarski et al., 2021), with the greatest temperamental "loading" of Present-Hedonistic (about 40%–50% of variance explained by BIS/BAS dimensions), moderate effects of temperament on Past-Negative, Present-Fatalistic, Future-Positive, and Future-Negative (about 10%–30% of variance), to a lack of significant effects of BIS/BAS features on Past-Positive. Based on these data we hypothesized that the estimations of genetic components of variance could form a similar rank ordering.

1.2.2 | Nature of environmental influences

Typically, though not invariably, unshared environmental factors contribute more to trait variation than shared factors (Plomin, 2011). However, the environmental factors listed by Zimbardo and Boyd (2008) are primarily shared ones, such as familial background, religion, culture, and education. By contrast, for the vast majority of specific individual differences, the model explaining total variance solely with the additive genetic variance and non-shared environmental variance proved to best fit the empirical data (Vukasović & Bratko, 2015). Thus, unless TP has unusual developmental antecedents, it is expected that non-shared environmental influences should predominate over shared ones.

1.2.3 | Covariance of genetic and environmental factors

Behavior-genetic analyses may also reveal how underlying sources of variation covary. Genetic covariance analysis may reveal associations and overlaps between factors that are not evident in data on associations between phenotypes (Livesley et al., 1998; McRae et al., 2001). The analyses of covariance here were exploratory, given the lack of previous behavior-genetic studies of TPs. However, if heritability of TPs is partly driven by temperamental factors, it is expected that there should be a genetic correlation between Past-Negative and Future-Negative, and between Past-Positive and Future-Positive, reflecting the influences of genes for temperamental negative and positive affectivity, respectively.

1.2.4 | Genetic and environmental covariances between TPs and Big Five dimensions

Given the considerable overlaps between TPs and personality traits (Kairys & Liniauskaite, 2015), we also aimed to determine to what extent these covariances stem from their shared genetic basis. Zimbardo and Boyd (1999, 2008) seem to treat these associations as validity markers of their TP questionnaire, however, the robustness of these associations seems to undermine their claims on the environmental roots of TPs. If the majority of these covariances result from their common genetic underpinnings, the claims on mainly environmental bases of TPs would have to be rejected. Moreover, such a result would partly uncover the nature of the individual biases in temporal foci.

A plausible genetic hypothesis is that biologically based temperamental factors evident from early childhood influence the development of both adult personality and TPs, together with environmental factors (Stolarski et al., 2021). Models of temperament (Caspi & Shinar, 2006; Matthews et al., 2009) link multiple dimensions to genetic bases (Gagne & Goldsmith, 2020; Takahashi et al., 2007), and well-being across the lifespan (Nes & Roysamb, 2015). The influential temperament model of Rothbart and Bates (2006) identifies three biologically based dimensions. *Negative emotionality* reflects susceptibility to a range of negative emotions supported by the Behavioral Inhibition System (BIS), the brain system for punishment and avoidance that underpins adult neuroticism (Corr & McNaughton, 2012). We hypothesize it may influence negative-valent TPs. *Surgency* refers to positive emotionality, activity, and social approach tendencies, supported by brain reward/approach circuits (the Behavioral Activation System or BAS: Corr & McNaughton, 2012). Surgency may be a precursor to both extraversion and positive-valent TPs. *Effortful control* is characterized by inhibitory self-control and attentional focusing, supported by brain systems for executive control, similar to adult conscientiousness. Conceptually, effortful control resembles Zimbardo's Future TP in its focus on future planning and delay of gratification. However, the division of Future TP into Future-Positive and Future-Negative (Carelli et al., 2011) suggests that temperamental origins of future-oriented TPs may also reflect emotionality factors. Empirically, Future-Positive correlates substantially with conscientiousness but not extraversion, suggesting a basis in effortful control (Stolarski & Matthews, 2016). By contrast, Future-Negative is most strongly associated with neuroticism, with a smaller *negative* association with conscientiousness, implying it primarily reflects negative emotionality (Stolarski & Matthews, 2016). The temperamental hypothesis predicts genetic correlations between phenotypic personality traits and congruent TPs. However, environmental factors might also play a role; for example, adverse life events might affect both neuroticism and negative TPs (e.g., Styła et al., 2019).

Moreover, following the ongoing debate regarding the existence and role of higher order personality traits (see e.g., Just, 2011), we also investigated the genetic and environmental associations between TPs and the General Factor of Personality (GFP; Musek, 2007). We anticipated overlaps between the GFP and BTP on conceptual grounds. Each is a meta-level feature that emerges from a set of separate albeit interrelated traits (see Stolarski et al., 2018; van der Linden et al., 2016). Second, since these two meta-level personality constructs both have clearly adaptive features, it seems highly probable that they are markedly interrelated. van der Linden et al. (2016) link the GFP to adaptive, long-term life history strategies that also contribute to adaptive, future-oriented TP (Dunkel & Kruger, 2015). With GFP being substantially heritable (van der Linden et al., 2016), it seems vital to test whether its hypothesized overlap with BTP stems from their shared genetic basis.

2 | METHODS

2.1 | Participants and procedure

Participants were 411 Polish same-sex twin pairs, reared together. Three hundred couples were recruited by a professional research company, paid for the recruitment service. The remaining part of the sample comprised twin couples recruited via internet advertisements and during twins festivals—social events annually organized in Poland, aiming to gather the twin community, celebrate their uniqueness, and allow for the exchange of life experiences among twin couples. Zygosity was diagnosed by the Polish version of the Questionnaire of Twins Physical Resemblance (QTPR; Oniszczenko & Rogucka, 1996). The predictive accuracy of the scale reaches 93.9% (96.2% for monozygotic and 90% for dizygotic pairs). In the case of a discrepancy between QTPR-based and self-reported zygosity, couples were excluded from the analyses. The ultimate sample comprised 393 same-sex twin pairs, reared together. Among them, 135 were classified as monozygotic (MZ) and 258 as dizygotic (DZ) twins. MZ twins (88 females, 47 males) were aged between 15 and 48 years ($M = 24$, $SD = 7.1$) and DZ (189 females and 69 males) were between 15 and 57 years ($M = 21.9$, $SD = 5.6$). It is worth mentioning that the recruitment procedure possibly yielded the unexpected preponderance of DZ twins relative to MZ twins (usually the ratio is just the opposite). The most plausible explanation of this effect is associated with the fact that the research company was informed that DZ are harder to recruit, so they put more effort to find these participants.

Questionnaires were administered on a group basis, in university class settings, by one of five trained research assistants—doctoral students taking part in a research project conducted by the first author of the present article. Twin pairs were tested together at the same time and place. The study was anonymous. All participants gave written informed consent to take part in a study of “the origins of attitudes towards time.” Immediately after test completion, pollsters checked for any missing data in the questionnaires and, if necessary, asked participants to supplement their answers. This procedure ensured that no data were missing. Questionnaire booklets coming from the same pairs were specially coded, in order to enable matching their data. Each of the participants received a remuneration of approximately 20 USD.

2.2 | Measures

During the project, the participants completed a set of questionnaires, measuring individual differences in TPs, intelligence, and personality. The dataset used in the present analyses is publicly available at Mendeley Data (Stolarski, 2022).

Time perspectives were measured with a 64-item version of the Zimbardo Time Perspective Inventory (ZTPI). It consists of six subscales: Four initially proposed by Zimbardo and Boyd (1999): Past-Negative (PN), Past-Positive (PP), Present-Hedonistic (PH), Present-Fatalistic (PF), and the Carelli et al. (2011) scales for Future-Positive (FP), and Future-Negative (FN). Participants rated each item on a five-point Likert scale (see Table 1 for descriptive

TABLE 1 Descriptive statistics and covariances of TP scales in an overall sample of twins.

Scale	*M*	*SD*	Skewness	Kurtosis	1.	2.	3.	4.	5.	6.	7.
1. Past-Negative	2.98	0.79	0.18	−0.65	–	−0.19*	0.13*	0.46*	−0.15*	0.50*	0.80*
2. Past-Positive	3.67	0.59	−0.57	0.40		–	0.11*	0.01	0.14*	0.06	−0.37*
3. Present-Hedonistic	3.51	0.55	−0.13	−0.46			–	0.35*	−0.21*	−0.01	0.06
4. Present-Fatalistic	2.55	0.64	0.28	−0.25				–	−0.33*	0.39*	0.67*
5. Future-Positive	3.52	0.61	−0.32	−0.14					–	−0.04	−0.33*
6. Future-Negative	3.22	0.56	−0.01	−0.22						–	0.67*
7. DBTP	2.66	0.79	0.44	0.01							–

Note: Scales scores were calculated as items' means based on raw data. Covariances were calculated on scores corrected for gender and age.

Abbreviation: DBTP, deviation from the balanced time perspective.

$^*p < 0.05$.

statistics and covariances between the ZTPI scales). The support for the superiority of the six-factor solution over the original five-factor in the Polish population was provided by Jochemczyk et al. (2017).

Balanced time perspective was measured using the Deviation from the Balanced Time Perspective (DBTP) coefficient proposed by Stolarski et al. (2011), validated against other indicators of temporal balance by Zhang et al. (2013). The coefficient is computed using a quasi-Euclidean distance formula and reflects the discrepancy between an individual's actual profile of ZTPI scores and the theoretical “optimal” profile of ZTPI scores. Given that the present study applied the six-dimensional version of the ZTPI scale, we have used the broadened DBTP formula, endorsed by Rönnlund et al. (2017):

$$DBTP = \sqrt{(oPN - ePN)^2 + (oPP - ePP)^2 + (oPF - ePF)^2 + (oPH - ePH)^2 + (oFP - eFP)^2 + (oFN - eFN)^2}$$

where o = observed and e = expected (i.e., “optimal”) score according to Zimbardo and Boyd (2008): ePN = 1.95, ePP = 4.60, ePF = 1.50, ePH = 3.90, eFP = 4.00, eFN = 1.80 (see the rationale for the “expected” points provided by Zhang et al., 2013; Rönnlund et al., 2017). Lower DBTP scores indicate a more balanced profile of TP dimensions. Results of numerous studies conducted using the DBTP indicator provide robust evidence for the indicator's validity (see Stolarski et al., 2020, for a systematic review).

Big Five personality traits were measured using the 50-item set of International Personality Item Pool Big Five Factor Markers (IPIP-BFM-50) questionnaire (Goldberg, 1992) in the Polish adaptation by Strus et al. (2017). The measure includes five scales: extraversion (E), agreeableness (A), conscientiousness (C), emotional stability (ES), and intellect/imagination (I). It has a five-point Likert-type response format, from 1-very inaccurate to 5-very accurate. Psychometric properties of the Polish version were tested on a large sample, showing sufficient internal consistency (Cronbach αs ranging from 0.73 to 0.91) and proper convergent validity (associations with other established Big Five measures). In this report, Big Five data were analyzed only to provide a comparison with the ZTPI for the magnitude of genetic influences in the present sample.

The General Factor of Personality (GFP) was obtained using exploratory factor analysis conducted using Principal Axis Factoring (PAF) on the IPIP scale scores. The GFP values were saved by regression method and later split into twins' scores. The factor loadings were equal to:0.68 for E, 0.38 for C, 0.27—A, 0.36—ES, and 0.36—I, with the variance for all twins equal to 0.58 (for this reason the covariances of GFP are also reported).

3 | PROCEDURE FOR DATA ANALYSIS

The most popular behavior-genetic paradigm, based on a twin method with monozygotic (MZ) and dizygotic (DZ) same-sex twins reared together, implies that the phenotypic variance of a trait can be explained by four latent variables (Neale & Cardon, 1992)—additive and non-additive genetic, shared and non-shared environmental factors:

1. Additive genetic factor (A) is the same for MZ twins (who share identical genes), whereas DZ twins share on the average only 50% of genes; it implies that the expected resemblance of MZ twins should be two times higher than for DZ twins.
2. Non-additive genetic factor (D), comprising dominance effect and epistasis, is fully shared by MZ twins and only in 25% of DZ twins—this factor may explain the lower similarity of DZ twins, relative to expectation on the basis of impact of additive factors.
3. Shared environment (C) influences the differences between pairs of twins, but has the same impact on the resemblance of twins within the pair—this factor is responsible for higher similarity of DZ twins, relative to impacts of additive genetic factor (see Neale & Cardon, 1992). In twins reared together, the impact of all within-family environmental factors is the same for MZ and DZ pairs.
4. Non-shared environment (E) influences dissimilarity of both twins and is indicated by the non-perfect resemblance of MZ twins (and also comprises the error variance).

The behavior-genetic models also assume that there is no assortative mating effect with regard to personality traits (parents are matched randomly). Based on twin data, the following hypotheses are tested: (1) the data do not indicate any family resemblance (only E model), (2) family resemblance is caused by an additive genetic factor (AE model), (3) family resemblance is caused by a non-additive genetic factor (DE model—for theoretical reasons analyzed only when other models do not fit the data; see Neale & Cardon, 1992), (4) family resemblance is caused by common environmental factors for both twins (CE model), (5) family resemblance is caused by both types of genetic effects (ADE model) and finally (6) family resemblance is due to the additive genetic effect and shared environment (ACE model). Due to methodological reasons, in studies of twins reared together, the impact of non-additive genetic factors and shared environment cannot be simultaneously estimated (e.g., DCE and full ADCE model; Neale & Cardon, 1992).

Statistical procedures aimed at testing the above hypotheses were based on a maximum-likelihood model fitting to twin data in order to estimate the influence of genetic and environmental factors (Neale & Cardon, 1992). The variances/covariances of the trait were calculated independently for MZ and DZ twins, after correction for age and gender. The selection of the model was based on the significance of the χ^2 test (Jöreskog & Sörbom, 1993). The models which showed a significant χ^2 value (indicating non-acceptable fit) were rejected (usually E, and in the case of particular TPs sometimes also CE model). The more complex ADE and ACE models were tested against AE and CE ones for significant improvements of fit ($\Delta\chi^2 > 3.84$, for $\Delta df = 1$, $p = 0.05$). When AE and CE were similarly fitted to the data, and each one did not show a statistically significantly worse fit than the more complex ACE model, the results of both models were accepted (i.e., the data supported both hypotheses, partly because the models cannot be directly compared and both were fitted well to the data). Aside from the univariate models, the multivariate models were fitted to the data with the aim of extracting the genetic and environmental components of phenotypic variances of all six time perspectives. First, the genetic and environmental covariances (and correlations) were derived via Cholesky decomposition (Neale & Cardon, 1992) which provided the estimation of the common additive genetic (A) and environmental (E) factors for all TP dimensions and, subsequently, were also tested by the independent pathway model. Cholesky decomposition simply split variances and covariances among traits into genetic and environmental components. This analysis was restricted to previously selected models AE and CE models in univariate analyses. Independent pathway model was applied to answer the question about a common genetic and environmental main factor of all phenotypic TPs. The analysis was restricted to the AE model because Cholesky decomposition based on the CE model showed an unacceptable fit (Vukasović & Bratko, 2015). The Cholesky model was also applied to estimate genetic and environmental components of covariances among BF and TPs.

4 | RESULTS

Descriptive statistics and covariances of the ZTPI subscales are provided in Table 1 (see also Appendix S1 for similar analyses conducted separately for twin 1 and twin 2). The intraclass correlations for MZ and DZ twins for TP and results of univariate genetic model fitting (indices of fit as well as standardized genetic and environmental variances) for all TPs are presented in Table 2. Model E in the case of all TPs did not show acceptable fit, whereas models ADE and ACE did not show significant improvement of fit than simpler AE or CE models.

Only for Past-Negative and Present-Fatalistic TPs the hypothesis of a purely environmental basis was not unambiguously rejected (AE and CE models showed comparable fit). In the remaining cases, the genetic influence was clear, providing evidence for a marked heritability of analyzed features.

It is worth noting that the additive genetic effects were very robust and ranged between 50% and 60% of variance ($M = 56\%$), which is significantly greater than values obtained in other Polish samples for the Big Five personality dimensions or traits distinguished in the Regulative Theory of Temperament (usually estimated at approx.

TABLE 2 Intraclass correlations for MZ and DZ twins for time perspectives and results of univariate genetic models.

Scale	α	MZ ICC	DZ ICC	Model	χ^2	*df*	*p*	e^2 (95% CI)	a^2 (95% CI)	c^2 (95% CI)
Past-Negative	0.84	0.50*	0.35*	AE	2.85	4	0.58	0.47 (0.38–0.57)	0.53 (0.41–0.67)	0.40 (0.31–0.53)
				CE	3.07	4	0.55	0.60 (0.52–0.69)		
Past-Positive	0.66	0.56*	0.29*	AE	4.91	4	0.30	0.40 (0.32–0.50)	0.60 (0.48–0.74)	
Present-Hedonistic	0.80	0.64*	0.22*	AE	5.64	4	0.23	0.38 (0.30–0.47)	0.62 (0.50–0.76)	
Present-Fatalistic	0.70	0.48*	0.34*	AE	3.68	4	0.45	0.49 (0.39–0.59)	0.51 (0.39–0.65)	0.39 (0.29–0.51)
				CE	3.50	4	0.48	0.61 (0.53–0.70)		
Future-Positive	0.78	0.53*	0.25*	AE	7.15	4	0.13	0.44 (0.35–0.54)	0.56 (0.44–0.70)	
Future-Negative	0.61	0.60*	0.22*	AE	2.09	4	0.72	0.44 (0.35–0.54)	0.56 (0.43–0.70)	
DBTP	–	0.56*	0.38*	AE	4.79	4	0.31	0.37 (0.30–0.46)	0.63 (0.51–0.77)	

Note: e^2—variance attributed to non-shared environmental factor, c^2—variance attributed to shared environmental factor, a^2—variance attributed to additive genetic factor (d^2—variance attributed to non-additive genetic factor).

Abbreviations: CI, confidence intervals; DBTP, deviation from the balanced time perspective; ICC, intraclass correlation.

*$p < 0.05$.

40%; Zawadzki et al., 2000, 2001). As the present study also included a Big Five measure, we additionally tested whether the surprisingly high heritability indices were specific for TPs or might be sample-specific. The estimations of the Big Five personality traits (see Appendix S2 for the analogical analysis of the IPIP scores) also proved elevated—their mean broad heritability amounted at an average of 55% (range: 47%–65%). Higher estimations of the additive genetic factor have been observed for multivariable models, taking into account not only self-reports, but also observer ratings (i.e., models explaining the variance shared by self- and observer rating). In such analyses the heritability estimates may reach ⅔ of traits' variance, thus exceeding the values obtained in the present study (see e.g., Riemann et al., 1997).

A multivariate Cholesky model assuming the impact of specific and common environmental factors (CE) on variances and covariances among six TPs showed a non-acceptable fit: $\chi^2 = 181.73$, $df = 114$, $p = 0.0001$, whereas a Cholesky model assuming the impact of specific environmental factor and additive genetic factor (AE) fitted the data well: $\chi^2 = 137.94$, $df = 114$, $p = 0.063$. It means that all TPs (and their covariances) may be explained better by the impact of genetic and environmental factors than by only environmental ones. The results of Cholesky decomposition are presented in Table 3. Genetic and environmental correlations were calculated based on the formula provided by Neale and Cardon (1992).

To sum up, although we cannot exclude the possibility that Past-Negative and Present-Fatalistic may be explained solely by environmental factors, the entire structure of TPs is best reflected in the AE model. However, independent pathway models assuming the impact of the common genetic (A) and environmental (E) factors for all TPs failed: $\chi^2 = 289.59$, $df = 132$, $p = 0.001$. It means that the genetic and environmental background of all TPs cannot be reduced to the same genetic and environmental factors—common genetic and environmental factors do not explain the covariance of TPs. In other words, the universe of TP dimensions cannot be attributed to one common genetic and environmental factor.

Finally, the genetic and environmental components of covariances among Big Five, and TPs (including DBTP) were estimated by a multivariate Cholesky AE model. The phenotypic intercorrelations between these dimensions were consistent with the results of the previous studies (e.g., Kairys & Liniauskaite, 2015) and are presented in Table 4. All TP dimensions which are considered more or less adaptive (namely: Past-Positive, Present-Hedonistic, and Future-Positive) proved positively associated with GFP whereas an inverse pattern of associations was obtained for the “maladaptive” TPs (Past-Negative, Present-Fatalistic, and Future-Negative).

TABLE 3 Genetic and environmental covariances and correlations among perspectives, estimated by multivariate genetic Cholesky AE model.

EA model	Genetic (A) covariances and correlations						Environmental (E) covariances and correlations					
Scales	1.	2.	3.	4.	5.	6.	1.	2.	3.	4.	5.	6.
1. Past-Negative	0.53	−0.12*	0.07	0.36*	−0.15*	0.32*	0.47	−0.07*	0.06	0.10*	0.00	0.18*
2. Past-Positive	*−0.21*	0.60	0.09	0.00	0.11	0.06	*−0.16*	0.40	0.02	0.00	0.03	0.00
3. Present-Hedonistic	*0.12*	*0.15*	0.62	0.25*	−0.17*	−0.06	*0.14*	*0.05*	0.38	0.10*	−0.04	0.04
4. Present-Fatalistic	*0.69*	*0.00*	*0.45*	0.51	−0.19*	0.29*	*0.21*	*0.00*	*0.23*	0.49	−0.14*	0.10*
5. Future-Positive	*−0.28*	*0.19*	*−0.29*	*−0.36*	0.56	−0.05	*0.00*	*0.07*	*−0.10*	*−0.30*	0.44	0.01
6. Future-Negative	*0.59*	*0.10*	*−0.10*	*0.54*	*−0.16*	0.56	*0.40*	*0.00*	*0.10*	*0.22*	*0.02*	0.44

Note: Genetic and environmental variances are given on diagonals, covariances above diagonals (*$p < 0.05$), and correlations—below diagonals (in italic).

TABLE 4 Phenotypic correlations between TP dimensions and the Big Five traits.

Trait	Past-Negative	Past-Positive	Present-Hedonistic	Present-Fatalistic	Future-Positive	Future-Negative	DBTP
Extraversion	−0.24*	0.11*	0.34*	−0.08*	0.10*	−0.32*	−0.30*
Agreeableness	−0.04	0.24*	0.17*	−0.10*	0.15*	−0.08*	−0.18*
Conscientiousness	−0.19*	0.13*	−0.18*	−0.26*	0.67*	−0.15*	−0.32*
Emotional stability	−0.53*	0.08*	−0.03	−0.32*	0.06	−0.53*	−0.54*
Intellect	−0.09*	0.13*	0.16*	−0.10*	0.12*	−0.05	−0.14*
GFP	−0.33* (−0.25)	0.20* (0.15)	0.27* (0.21)	−0.21* (−0.16)	0.26* (0.20)	−0.38* (−0.29)	−0.44* (−0.34)

Note: Covariances among GFP and particular TP dimensions are given in parentheses.

Abbreviations: DBTP, deviation from the balanced time perspective; GFP, general factor of personality.

*$p < 0.05$.

All these correlations were of small magnitude (with $|r|$ ranging between 0.21 and.38). Consistent with our expectations, a stronger link was observed between GFP and DBTP—the two dimensions shared almost 20% of variance.

Genetic and environmental covariances of TPs and the Big Five dimensions are provided in Table 5, and the analogical analysis for DBTP is reported in Table 6. For conscientiousness, the DE model showed the best fit; however, the AE model also demonstrated an acceptable fit ($\chi^2 = 9.12$, $df = 4$, $p = 0.06$ with $e^2 = 0.39$ [95% CI: 0.31–0.48] and $a^2 = 0.61$ [95%CI: 0.49–0.75]). The results showed that genetic and environmental components of covariances among TPs and Big Five dimensions were substantial, but rather small. The highest genetic correlations were found for the “negative” TPs (Past-Negative, Present-Fatalistic, and Future-Negative) and Emotional Stability (in range: −0.74 to −0.49), markedly exceeding environmental correlations (−0.40 to −0.16). Among the “positive” TPs, only Future-Positive showed high genetic (0.79) and moderate environmental (0.51) correlation with only conscientiousness dimension, while small genetic correlations were found for both Past-Positive and Present-Hedonistic and the extraversion dimension. The links between TPs and GFP can also be attributed almost solely to the shared genetic factor. The only exception regards the Past-Positive dimension for which the environmental component of covariance with GFP was significant and greater than the genetic covariance.

For the DBTP coefficient, moderate/high genetic and small, mostly negligible environmental components of covariances with all Big Five dimensions were found (see Table 6). In other words, the marked covariance of temporal balance and personality traits stems mainly from their shared genetic basis. The only exception regards the link between DBTP and GFP. In this case, the genetic correlation between temporal disbalance and GFP proved strong and negative, whereas the environmental correlation was positive. We discuss this seemingly striking result later in the discussion section.

5 | DISCUSSION

The analyses conducted provide a seminal insight into the role of genetic factors in shaping individual differences in TPs. The present results are consistent with the vast majority of published twin studies of major personality dimensions in showing substantial heritability of traits (Vukasović & Bratko, 2015). Indeed, in studies of numerous human physiological and psychological traits, observed twin correlations generally imply a simple additive model (see the review by Johnson et al., 2008, and the meta-analysis by Polderman et al., 2015). Similarly, variance of TPs appears to be primarily attributable to additive genetic factors and the unshared environment. Conversely, the contribution of shared environmental variation and non-additive genetic variation to overall variance in TPs seems marginal. The findings are also consistent with the perspective from evolutionary psychology that TPs may be associated with differing life history strategies (Dunkel & Kruger, 2015). In the remainder of this discussion, we consider further the role of genetic and environmental factors in TP, findings from the analysis of genetic covariance, and study limitations.

5.1 | Genetic factors in time perspective

While discussing the nature of TP, Zimbardo and Boyd (1999, 2008) defined it as a response style, a cognitive bias, or a habitual tendency to focus on particular time horizons. As proponents of the situationist approach, they avoided discussing TP from the standpoint of theories of biologically based personality traits, even though they used highly heritable personality/temperament

TABLE 5 Genetic and environmental covariances and correlations among TPs and the Big Five dimensions.

Covariances	**Past-Negative (a_{cov})**	**Past-Negative (e_{cov})**	**Past-Positive (a_{cov})**	**Past-Positive (e_{cov})**	**Present-Hedonistic (a_{cov})**	**Present-Hedonistic (e_{cov})**
Extraversion	−0.16*	−0.08*	0.11*	0.00	0.24*	0.10*
Agreeableness	−0.06	0.04	0.16*	0.08*	0.07	0.10*
Conscientiousness	−0.19*	0.00	0.10*	0.03	−0.13*	−0.06*
Emotional stability	−0.33*	−0.20*	0.03	0.05	0.05	−0.08*
Intellect	−0.10*	0.01	0.05	0.08*	0.04	0.12*
GFP	−0.22*	−0.03	0.06	0.08*	0.24*	−0.04
Covariances	**Present-Fatalistic (a_{cov})**	**Present-Fatalistic (e_{cov})**	**Future-Positive (a_{cov})**	**Future-Positive (e_{cov})**	**Future-Negative (a_{cov})**	**Future-Negative (e_{cov})**
Extraversion	−0.08*	0.00	0.13	−0.03	−0.22*	−0.10*
Agreeableness	−0.17*	0.07	0.14*	0.01	−0.07	−0.01
Conscientiousness	−0.15*	0.09*	0.46*	0.21*	−0.16*	0.02
Emotional stability	−0.24*	−0.08*	0.07	−0.02	−0.38*	−0.15*
Intellect	−0.12*	0.02	0.12*	0.00	−0.05	0.00
GFP	−0.12*	−0.05	0.21*	−0.01	−0.31*	0.03
Correlations	**Past-Negative (a_{corr})**	**Past-Negative (e_{corr})**	**Past-Positive (a_{corr})**	**Past-Positive (e_{corr})**	**Present-Hedonistic (a_{corr})**	**Present-Hedonistic (e_{corr})**
Extraversion	−0.28*	−0.19*	0.18*	0.00	0.39*	0.26*
Agreeableness	−0.11	0.09	0.28*	0.19*	0.12	0.24*
Conscientiousness	−0.33*	0.00	0.17*	0.08	−0.21*	−0.16*
Emotional stability	−0.66*	−0.40*	0.06	0.11	0.09	−0.18*
Intellect	−0.20*	0.02	0.09	0.18*	0.07	0.27*
GFP	−0.38*	−0.07	0.10	0.21*	0.38*	−0.11
Correlations	**Present-Fatalistic (a_{corr})**	**Present-Fatalistic (e_{corr})**	**Future-Positive (a_{corr})**	**Future-Positive (e_{corr})**	**Future-Negative (a_{corr})**	**Future-Negative (e_{corr})**
Extraversion	−0.14*	0.00	0.22	−0.07	−0.38*	−0.24*
Agreeableness	−0.32*	0.15	0.25*	0.02	−0.13	−0.02
Conscientiousness	−0.27*	0.21*	0.79*	0.51*	−0.27*	0.05
Emotional stability	−0.49*	−0.16*	0.14	−0.04	−0.74*	−0.31*
Intellect	−0.24*	0.04	0.23*	0.00	−0.10	0.00
GFP	−0.21*	−0.12	0.35*	−0.03	−0.52*	0.08

Note: a_{cov}/a_{corr}—covariances/correlations due to the additive genetic factor; e_{cov}/e_{corr}—covariances/correlations due to the specific environmental factor. Correlations are presented in italics whereas covariences are presented in regular font.

Abbreviation: GFP, general factor of personality.

*$p < 0.05$.

TABLE 6 Genetic and environmental covariances and correlations between DBTP and the Big Five dimensions.

Covariances/ correlations	DBTP (a_{cov})	DBTP (e_{cov})	DBTP (a_{corr})	DBTP (e_{corr})
Extraversion	−0.22*	−0.08*	−0.35*	−0.21*
Agreeableness	−0.19*	0.02	−0.33*	0.05
Conscientiousness	−0.29*	−0.03	−0.47*	−0.08
Emotional stability	−0.38*	−0.16*	−0.70*	−0.36*
Intellect	−0.11*	−0.03	−0.20*	−0.07
GFP	−0.46*	0.13*	−0.72*	0.36*

Note: a_{cov}/a_{corr}—covariances/correlations due to the additive genetic factor; e_{cov}/e_{corr}—covariances/correlations due to the specific environmental factor. The bivariate Cholesky AE model for GFP and DBTP demonstrated an acceptable fit ($\chi^2 = 14.83$, $df = 14$, $p = 0.39$). Correlations are presented in italics whereas covariences are presented in regular font.

Abbreviations: DBTP, deviation from the balanced time perspective; GFP, general factor of personality.

*$p < 0.05$.

traits as convergent validity indicators for their measure of TPs. The marked role of genetic factors in shaping individual differences in TPs, demonstrated in the present study, is contrary to Zimbardo and Boyd's (1999, 2008) account, which focused almost entirely on the role of the environment (mainly education and culture). It seems that one's temporal profile does not depend solely on life experiences. Quite the opposite, the role of genetic predispositions, probably partly mediated by temperamental mechanisms (Stolarski et al., 2021), seems particularly strong: TPs apparently have a marked biological component, at least as big as standard personality traits. The heritability of TPs does not directly address their malleability. It remains possible that TPs can be changed by life events and external manipulations. Psychological interventions to address maladaptive lack of balance in TP may sometimes be desirable (see Oyanadel et al., 2014). However, it may be necessary to take into account the person's typical stability in TP which is driven by innate factors.

It may be hypothesized that the heritability of TPs reflects the extent to which each TP is driven by biologically based temperamental factors for emotionality. In this case, the rank ordering of the six dimensions of TP should parallel the extent to which they overlap with the temperamental BIS/BAS dimensions (Stolarski et al., 2021). Thus, heritability should be highest for Present-Hedonistic and lowest for Past-Positive. This hypothesis was not confirmed. Heritability values (a^2) were fairly similar for each scale, ranging from 0.51 to 0.62. It is not clear that these modest inter-scale differences reflect anything more than chance. As expected, Present-Hedonistic had the highest heritability (0.62) but Past-Positive, which is largely unrelated to BIS/BAS, had the second highest (0.60). It appears that there is more to the genetic bases for TP than simply positive and negative affectivity. Other temperamental factors such as effortful control (Rothbart et al., 2020) may also shape TP. There may also be genes that uniquely influence TP.

A surprising finding was that estimates of the role of the additive genetic factor proved higher than in behavioral genetic studies of personality conducted to date in the Polish samples (ranging from 0.38 to 0.49, at average 0.44 for self-report of temperamental traits; see Zawadzki et al., 2001 and from 0.32 to 0.41, at average 0.37 for Big Five personality dimensions; see Zawadzki et al., 2000). However, the difference does not necessarily imply that TPs are heritable to a greater extent than personality traits. Heritability of the Big Five traits obtained in the present sample also seemed elevated. In their meta-analysis, Vukasović and Bratko (2015) reported a 95% confidence interval of 0.45–0.49 for heritability of major trait dimensions measured in twin studies (other designs gave lower estimates). Here, three of the Big Five showed heritabilities outside that interval, and the highest heritability of 0.65 was for conscientiousness (see Appendix S2). Vukasović and Bratko (2015) reported a confidence interval of 0.28–0.45 for the Big Five version of that trait. Thus, the present elevation of heritabilities may be a chance sampling effect.

A further consideration is that the previous twin studies of the Big Five in Poland were conducted in the late 1990s (e.g., Zawadzki et al., 2001); thus, the difference in heritability estimates may partly result from cultural changes. At least since 2002, we may observe a systematic decrease in socioeconomic stratification in Poland (The World Bank, 2022), so there is now less environmental variability. As a result, the effects of the environmental factor (E) may be lower than 20–25 years ago.

It is also worth noting that estimations of heritability are usually higher in multivariate models combining self- and peer-ratings (reaching ⅔ of variance; cf., Riemann et al., 1997). A replication of the present findings using methodology supplemented with peer-rating of TPs would thus be plausible.

5.2 | The role of the environment

As for other traits (Plomin et al., 2016), results confirm an important role of environmental factors in shaping TP. Also similar to traits in general, unshared factors seemed more influential than the shared, family environment. The nature of unshared environmental influences remains something of a mystery in personality research: studies have failed to confirm major roles for specific factors that may differ across siblings such as different peers and unique life events. Similar to how many different genes may make small contributions to heritability

(Plomin et al., 2016), many unique events may contribute to variance in TPs (Kandler & Zapko-Willmes, 2017; Turkheimer & Waldron, 2000).

Present findings suggested that two of the TP dimensions - Past-Negative and Present-Fatalistic—may still remain under significant influences of the shared environment factor. It is unclear why these two particular dimensions should be more susceptive to shared environments. However, there may be specific factors that contribute to this effect (Styła et al., 2019), such as actual childhood adversities experienced in the family of origin, which might contribute to Past-Negative TP. In contrast, in the case of the remaining TPs, the effect of the shared environment seems negligible. It has also proved difficult to demonstrate the impact of family environment variables on the temporal dimensions. A recent longitudinal study of adolescents (Stolarski et al., 2020) provided evidence for the marked effects of temperament on temporal change in individual differences in TPs. It also found that, while family environment variables including cohesion and conflict were correlated with TPs in cross-sectional data, there was no relationship between environment and TP in longitudinal analyses, contrary to the idea of the family as a causal influence on TP development.

5.3 | Genetic and environmental covariances

For the most part, the multivariate Cholesky model suggested genetic covariances were not very high, and the environmental factors appeared to be even more independent from one another. Broadly, divergence of factors suggests that there are multiple causes of TP variation. However, there was a tendency for the three most maladaptive elements of TP, Past-Negative, Future-Negative, and Present-Fatalistic, to inter-correlate. This clustering is consistent with our tentative hypothesis that negative affectivity might influence both Past- and Future-Negative TPs at the genetic level. On the contrary, Past-Positive and Future-Positive were minimally associated, suggesting that there is no corresponding genetic influence of positive affectivity. Future-Positive TP may be influenced by genes for executive control and planning, which attach more to the effortful control aspect of temperament than to positive affect (Rothbart et al., 2020). Non-shared environmental factors were more weakly organized by affect. There was a significant positive association between Past- and Future-Negative TPs suggesting a common environmental influence; for example, both might be concurrently affected by negative life events. However, similar to the genetic factors, the correlation between Past-Positive and Future-Positive was close to zero. In general, the covariance findings point toward individual TPs having complex origins that may often be unique to the specific dimensions.

5.4 | Genetic vs. environmental covariances between TPs and Big Five

The pattern of the associations between TPs and the Big Five personality traits proved similar to those reported in previous studies (Kairys & Liniauskaite, 2015; Stolarski & Matthews, 2016)—both Past-Negative and Future-Negative were strongly associated with low emotional stability, Future-Positive was related to markedly higher conscientiousness, whereas Present-Hedonistic was accompanied by higher extraversion (see Table 4). The decomposition of these covariances between genetic and environmental factors revealed that the role of the former is clearly greater.

Genetic correlations were consistent with the temperamental hypotheses advanced in the introduction. As expected, Past-Negative, Present-Fatalistic, and Future-Negative all displayed substantial genetic associations with low emotional stability. Among them, the most pronounced genetic correlation with stability was observed for Future-Negative (−0.74), plausibly due to the high loading of trait anxiety (Carelli et al., 2011). Genetically based neurotic tendencies seem to shape a considerable portion of variance in the "negative" TP dimensions. In light of this result, it seems justified to ask to what extent do the well-established, marked effects of these TPs on well-being (e.g., Stolarski & Matthews, 2016) result from the shared genetic bases between these dimensions.

The positive-valent TP dimensions were more weakly associated with the Big Five at the genetic level than were the negative TPs. Brain reward systems influenced by genes such as the BAS are seen as a major temperamental basis for extraversion (Caspi & Shinar, 2006). However, in the present genetic correlation data, extraversion was unrelated to Future-Positive, weakly related to Past-Positive (0.18), and moderately associated with Present-Hedonistic (0.26). These dissociations between positive TPs may reflect the differentiated nature of positive affectivity. In the Rothbart and Bates (2006) temperament model, the broad surgency factor covers activity and social approach as well as positive emotionality; these components may differ somewhat in their genetic bases. In adults, the genetic bases for activity and positive emotionality are correlated but dissociable (Røysamb et al., 2018). Similarly, studies of the BAS believed to underpin positive affectivity, identify multiple dimensions including reward interest, goal drive-persistence, reward reactivity, and impulsivity in both children and adults (Vecchione & Corr, 2021; Vervoort et al., 2019). To date, genetic correlation studies of the BIS/BAS personality model (Corr & McNaughton, 2012) have investigated the BAS only as a unitary construct (e.g., Smederevac et al., 2022; Takahashi et al., 2007), so the extent of genetic overlap between different BAS components is unknown. Gooding et al. (2021) found evidence for substantial unique genetic variance associated with multiple positive affectivity scales, as well as some shared genes. A greater understanding of the genetic bases for positive affectivity is necessary to understand how its various components may influence positive TPs and extraversion in adulthood.

We also confirmed the hypothesis that Future-Positive TP would have a genetic basis in common with conscientiousness, assuming both are influenced by temperamental effortful control (Rothbart & Bates, 2006). The amount of the genetic covariance shared between the TP and conscientiousness (0.46) was more than twice as high as the environmental covariance (0.21) of these dimensions. These results clearly undermine the claim that "no gene pushes people into future time zone" (Zimbardo & Boyd, 2008, p. 137). Actually, in light of the present results, the opposite seems to be true: not only is Future-Positive markedly heritable (with the estimate of additive genetic factor amounting to 0.56) but it also shares a large part of its genetic basis with conscientiousness. Biologically based temperamental factors that steer the child toward self-control and delay of gratification (Rothbart et al., 2020) may influence both conscientiousness and future orientation. By contrast, Future-Positive showed only weak genetic associations with extraversion and the other positive TPs, suggesting that genes for positive affectivity may have only minor impacts on this TP.

Finally, it seems vital to note the significant genetic correlations with all Big Five traits observed for the meta-level TP feature, that is, the DBTP. Such a pronounced genetic overlap with all personality features suggests that DBTP, created as an indicator of temporal (dis)balance (Zhang et al., 2013) has genetic origins in common with broad personality traits, especially emotional stability. Moreover, DBTP proved markedly genetically linked with the GFP, consistent with the claims of those theorists who interpreted GFP as a generalized, innate social effectiveness (van der Linden et al., 2016). Similarly, low DBTP indicates general temporal adaptation, supporting superior socio-emotional effectiveness (Stolarski et al., 2020; Zimbardo & Boyd, 1999). However, probably the most interesting finding refers to the fact that environmental covariance between GFP and DBTP proved positive. This result may indicate that the development of temporal balance may partly stem from some form of compensation mechanism, allowing low-GFP individuals to cope with the consequences of their maladaptive personality profile.

5.5 | Limitations and future directions

The present study has all the limitations characteristic of cross-sectional twin designs, including the possibility of inflation of the estimates of heritability due to biological confounding factors (Segalowitz, 1999), or all the problematic issues associated with the generalizability of results from twin studies on general population (i.e., the issue of representativeness of twins; Record et al., 1970). On the contrary, underestimations of the heritability estimates are also possible (e.g., resulting from non-random assortative mating for TP, stemming from the fact that MZ twins are in fact not 100% genetically identical due to post-zygotic changes in DNA, or epigenetic effects that might influence overall gene expression, or associated with measurement error/low reliability of the applied scales, as well as other sources such as chorionicity; see e.g., Marceau et al., 2016; Polderman et al., 2015; Trent, 2005). Furthermore, the fact that heritability indices always refer to a particular population further limits the generalizability of the present findings (see Simons et al., 2018). Moreover, Cronbach's α for Past-Positive and Future-Negative were relatively low which may limit the reliability of the estimations of genetic/environmental influences on these TP dimensions.

The cross-sectional design cannot pick up developmental changes in the influences of genetic and environmental factors and the interplay between them. Kandler et al. (2021) discuss how the contribution of genetic and environmental sources to individual differences varies across the lifespan. For example, the role of unshared environments may increase as children grow older and have more scope for selecting their own environments. Indeed, modeling may confound non-shared environmental factors with non-shared genotype × environment interaction (Purcell, 2002). The evolutionary perspective on TPs (Dunkel & Kruger, 2015) also suggests that future research could look systematically at gene–environment interaction. Studies performed in disadvantaged or marginalized groups in which short-term adaptive strategies predominate might provide a different picture of genetic and environmental influences to the present study. LHT (Kruger, 2021) also anticipates variation in influences over the lifespan.

TPs (particularly BTP) display vital associations with various features of well-being (e.g., Boniwell et al., 2010; Zhang et al., 2013). Most of the researchers interpreted this association in terms of causal effects of the former on the latter. In light of the present data, future studies could seek to decompose the covariance between these features and determine genetic correlations between them. Both these constructs seem to have a pronounced genetic component (see Bartels, 2015, for a meta-analysis of heritability of well-being); thus, much of the seemingly causal effect may in fact stem from their genetic covariance. However, progress depends on future work to unpack multiple aspects of the genes that shape temperament, especially in the case of positive affectivity.

6 | CONCLUSION

Zimbardo and Boyd's (2008) theory of individual differences in TP emphasized the impacts of the family and the cultural environment. Evidence from the twin study reported here challenges this account of TP. All six TPs defined by previous research were substantially heritable, similar to other dimensions of personality and temperament. Furthermore, unshared environment explained more of the variation in TP than shared factors such as family and culture, as is typical for other traits. Analyses of genetic correlations suggest that shared genes make a substantial contribution to phenotypic variability in the three negative-valent TPs and emotional stability. However, the positive TPs are more differentiated genetically from each other and extraversion. Future-positive TP is more closely related to conscientiousness than to extraversion, possibly reflecting the common influence of brain circuits for effortful control. Zimbardo and Boyd (2008) made a major and influential contribution to understanding how personality is shaped by the individual's time horizons, but future work should address the interplay of social and biological factors in guiding the development of TPs.

AUTHOR CONTRIBUTIONS

Maciej Stolarski—conceptualization; funding acquisition; methodology; project administration; supervision; writing—original draft; Bogdan Zawadzki—methodology; formal analysis; writing—original draft; Gerald Matthews—writing—original draft; writing—review and editing; Dominika Pruszczak—investigation; data curation; Jerzy Wojciechowski—methodology; data curation.

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CONFLICT OF INTEREST STATEMENT

The authors report no conflict of interest.

DATA AVAILABILITY STATEMENT

The dataset used for the present analysis has been published in the Mendeley Data repository: Stolarski, M. (2022). Behavioral genetic study of time perspectives. *Mendeley Data, V1*, doi: 10.17632/gn7bxdg7sk.1

ETHICS STATEMENT

The current research has been accepted by the institutional Ethics Committee at Faculty of Psychology, University of Warsaw, Poland.

PREREGISTRATION

The study was not preregistered.

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