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Review article

Beyond culture and the family: Evidence from twin studies on the genetic and environmental contribution to values

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ABSTRACT

Human values are abstract goals, affecting decisions, choices and behavior (Schwartz, 1992). Despite much value research, there is a lack of research on the etiology of values, specifically potential genetic influences. We therefore reviewed all published twin studies on human values, classified as representing four higher order values across two bipolar dimensions: Self-transcendence versus Self-enhancement and Openness to change versus Conservation. Across most studies, and most values, monozygotic twins correlated more strongly than dizygotic twins, indicating genetic contribution to values. Significant heritability estimates ranged from 24.5 to 85.7%. The effects of the environment shared by family members were generally weaker. Finally, there was a contribution of the non-shared environment for all values. After discussing the implications for the neuropsychological research on values, we suggest several future research directions, which may help guide the future science of the etiology of values. We also discuss the possible discrepancy between our findings and theory and research on value socialization and discuss the interplay of genes and the environment in the development of values.

1. Introduction

Human values are a fundamental part of our identity and as such affect who we are (Hitlin, 2006). Values serve as guidelines in a person's life (Schwartz, 1992; Schwartz, 2012) and are involved in a very broad range of attitudes, choices and behavior (Arieli et al., 2019; Benish-Weisman, 2015; Pulfrey and Butera, 2013; Roccas and Sagiv, 2010; Sagiv et al., 2011; Verplanken, and Holland, 2002). Because of their centrality to human functioning, understanding the origin of values is of special importance. For centuries, thinkers from different disciplines, philosophers, psychologists, sociologists, and educators have attributed the development of values to family factors, often seeing it also as a duty of parenthood (Grusec and Goodnow, 1994; Knafo-Noam et al., 2020). In contrast, the biological origins of human values were largely ignored (Knafo and Spinath, 2011), although the relation of values to personality traits, which have been shown to be affected by genetics (Fischer and Boer, 2015; Roccas et al., 2002; Vukasović and Bratko, 2015) also raises the possibility of genetic influences.

In this article we pose the question: what are the genetic and environment contributions to human values? To answer this question, after defining values, we start by describing the environmental contribution to human values, explain why environmental factors are insufficient to account for all variability in human values, and how the genetic factor completes the picture. Next, we review past twin studies on values, and specifically genetic and environmental contributions. Finally, we discuss the role of gene-environment interplay and suggest future directions.

1.1. Values - content and structure

Human values are defined as desirable, abstract goals, varying in importance across individuals and groups, and typically stable over time and consistent across situations (Schwartz, 1992). Values serve as guiding principles for behavior, as principles to justify one's behavior, and as guides towards the evaluation of other people and of the self (Rokeach, 1973; Schwartz, 1992; Schwartz et al., 2012).

The most prominent framework for studying personal values in psychology is Schwartz's theory of human values (Davidov et al., 2008). According to Schwartz (1992) there are ten universal human value types, which are distinct in the type of motivational goals they express. The 10 values are listed in Fig. 1 along with their definitions.

According to Schwartz's theory, there is a structure of dynamic relationships among values, representing the compatibilities and conflicts among them. The ten basic values are organized in a circular structure according to the motivations they express; the closer the values in the

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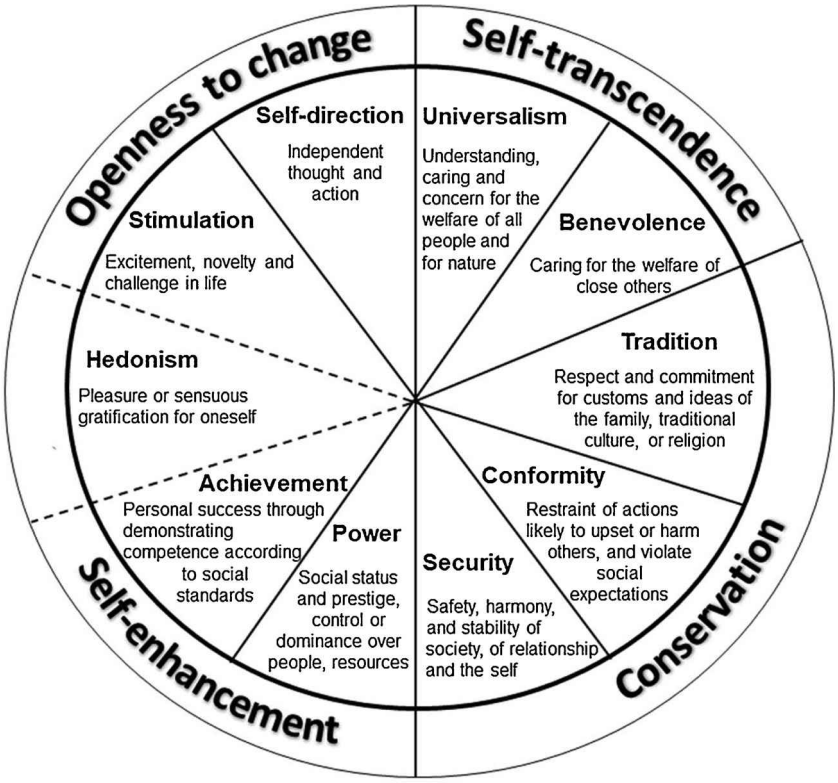

Fig. 1. Structure and definitions of values (Schwartz).
Note. a refined version of the value theory further organizes the universe of values into 19 values (see Schwartz, 2017); as there is still little developmental or genetic research using this refined theory, we focus on the classic 10-value theory.

circle are, the higher the similarity between their motivations, whereas conflicting motivations are reflected in opposite values. In addition, the values are interconnected and influence each other. Being high in a certain value means high probability of being high in the values close to it in the circle, but relatively low in the opposite values (Davidov et al., 2008; Maio et al., 2009). An important implication of this structure is that behaviors, attitudes and demographic variables that are positively related to a certain value tend to relate positively to the neighboring values, and negatively to the values at the opposite side of the circle (Fischer, 2017; Schwartz, 1992).

According to the theory, the ten values can be organized in four higher order values across two bipolar dimensions. The first dimension represents Self-transcendence values versus Self-enhancement values. Self-transcendence values contain the values universalism and benevolence, which emphasize care for the welfare of others, desire for equality and disengagement from selfish concerns, while Self-enhancement values contain power and achievement, that are motivated by emphasizing pursuit of individual dominance, success and property, even at the expense of others. The second dimension represents Openness to change values versus Conservation values. Openness to change values include stimulation and self-direction values and represent an autonomy motivation, and a focus on intellectual openness, adventure and novelty. In contrast, Conservation values include tradition, conformity and security, whose motivation concerns avoidance of change and preservation of the current social order, because of the certainty it provides. Hedonism shares elements with Openness to change and Self-enhancement (Schwartz, 1992, 2012).

1.2. Environmental influences on values

Traditionally, most researchers regarded value development as a result of environmental factors (Schönpflug, 2008; Schwartz, 2006a). The studies that concern values' etiology can be roughly divided to two prominent types of environmental contributions: demographic factors and family socialization. Values have been found to be predicted by socio-economic status (Hitlin, 2006; Kohn, 1989), education (Wray-Lake et al., 2014) and religiosity (Schwartz and Huismans, 1995). SES corelates negatively with conformity and positively with self-direction (Hitlin, 2006), and more specifically, low family's SES in middle childhood predicts high importance of Conservation values both concurrently (Uzefovsky et al., 2016) and towards adulthood (Kasser et al., 2002). Similar relationships have been found for education (Wray-Lake et al., 2014). In contrast, religiosity correlates positively with tradition, security and conformity, and negatively with hedonism and self-direction (Roccas and Schwartz, 1997). For adults, religiosity also correlates with giving high importance to Self-transcendence values and low importance to Self-enhancement values (Longest et al., 2013; Saroglou et al., 2004). The fact that among 7-year-old children, family religiosity was related to high importance of Conservation and low importance of Openness to change suggests that religiosity predicts values rather than the other way around, at least in childhood (Uzefovsky et al., 2016).

The second type of studies on environmental factors concerns family socialization. Researchers have found moderate positive correlations between children's values and their parents' values (Döring et al., 2016; Friedlmeier and Trommsdorff, 2011). A socialization model proposes that children learn what is important from relevant individuals; children look up to significant others, who are in most cases their parents, and internalize what they see (Grusec, 2011). In order to affect the child, parents have various tools, such as role modeling, conversation, teaching, reward for encouraging wanted behavior, or alternatively, punishment for prevention and extinction of unwanted behavior (Cladis, 1999; Grusec and Goodnow, 1994). The role of family socialization in the case of values is supported by findings such as the positive association between positive, warm parenting and parent-adolescent value similarity (Knafo and Schwartz, 2003). Additionally, the more accurate children perceive their parents' values, the greater the

similarity between the two generations (Grusec and Goodnow, 1994). Finally, the quality of the parent-child relationship has been found to predict stronger similarity between parents and children in their values (Knafo and Schwartz, 2012). Nevertheless, it is important to note that parent-child value similarity could reflect many additional processes, beyond parent-to-child influences (Knafo-Noam et al., 2020). As parents and children are genetically related in the vast majority of families, it is possible that parent-child similarity reflects, at least in part, their genetic relatedness (Knafo and Jaffee, 2013; Kandler et al., 2016).

2. Twin studies on values – a review

Although value researchers have largely ignored the possibility of a genetic contribution to values (Knafo-Noam et al., 2020), it is unlikely that genetic similarity between parents and their children has no effect on their similarity in values. Personality traits, attitudes, behaviors, even occupational preferences, all have been shown to relate to values (Boer and Fischer, 2013; Fischer and Boer, 2015; Knafo and Sagiv, 2004; Roccas and Sagiv, 2010) and all have been demonstrated as partly heritable (Nicolaou and Shane, 2010; Smith et al., 2012; Tesser, 1993; Vukasović and Bratko, 2015).

Most of the genetically-informative research on values has relied on the twin design. By comparing the phenotypic similarity between monozygotic twins, with virtually 100 % genetic similarity, to that of dizygotic twins, who share on average 50 % of the genetic variance, twin studies divide the phenotypic variance into its genetic and environmental sources. Specifically, the *heritability* of values is estimated (the proportion of variance in a specific sample accounted for by genetic variance), with the remaining variance attributed to environmental factors.

When twins are reared together, the environmental variance can be divided into *shared environment*, including all the environmental factors that family members share and make them similar, and the *non-shared environment*, referring to the combined effects of environment factors leading to dissimilarity between family members, as well as measurement error (Plomin et al., 2001). Thus, twin studies are not only informative about genetic influence, but also about the environmental influences making family members similar or dissimilar, beyond genetic influences.

In this paper we review all published twin studies on values. In addition to our literature search, we contacted over 100 twin researchers to inquire about availability of data on values. One team of authors shared with us an unpublished dissertation (Zapko-Willmes, 2018). We focused on values as defined by Schwartz (1992), and specifically abstract goals considered as important in people's lives, leaving out other variables that would be of interest but would not fall under this definition, specifically behavioral, attitudinal, and personality variables, such as religiosity, political opinion, and risk aversion. We located 11 twin studies of values. Of those, two pairs of studies included overlapping samples (Knafo and Spinath, 2011, and Kandler et al., 2016; and Waller et al., 1990 and Keller et al., 1992). Two studies used the twins-reared-apart design, and the rest used the classic twin design, including MZ and DZ twins reared together. Not counting overlapping samples, there were 3 twin studies of children and adolescents, and 6 studies of adults, in total.

Two pioneering studies investigated twins reared apart to understand the genetic contribution to values. In the first, Waller et al. (1990) studied the importance given to the value of religion, which is compatible with Conservation values, in the Minnesota Study of Twins Reared Apart. In this study 84 twin pairs with an average age of approximately 40 years rated their religious values. The difference in intraclass correlations between monozygotic and dizygotic twins, .55 and -.08, respectively, indicated a genetic contribution to religion values. Two years later, Keller et al. (1992), using the same sample, conducted research on a broad set of work values. Despite a modest number of pairs (N = 43), the fact the twins were reared apart made the design powerful. Although results tended to vary by value content, the researchers found 40 % heritability and an environmental contribution of 60 %, considering all values together.

The remaining twin studies of values used the classic twin design, in which MZ and DZ twins reared together are compared, enabling estimation of the effects of the shared and non-shared environment separately. Our review focuses on the presence of genetic and shared environment effects, which make family members similar to each other. All studies reported meaningful non-shared environment effects as well, which include measurement error, and are not discussed individually for each study. We organize our review based on Schwartzös (1992) higher-order values; Self-transcendence, Self-enhancement, Openness to change and Conservation)Fig. 1).

The only twin study to report results separately for all of Schwartz's 10 values was conducted on 690 individual Australian twins during early adulthood (18–33 years old) (Schermer et al., 2008). In all values, except achievement and hedonism, MZ twins showed higher correlations than DZ twins. Heritability estimates ranged from 0 (achievement), to 38 % (conformity). In addition to conformity, tradition and benevolence were the only values showing a significant genetic effect, as indicated by the confidence intervals. We note that these three values are adjacent in the Schwartz value structure (Fig. 1). Several values showed some evidence for a shared environment effect (especially, self-direction, tradition, and the Self-enhancement values of power and achievement), but these effects were not significant (Schermer et al., 2008).

In contrast, in a sample of 143 twin pairs from Canada, of similar ages but wider range, (13–45), researchers did not find any shared environment effect (Schermer et al., 2011). Heritability estimates ranged from 36 % for enjoyment (similar to hedonism) to 63 % for prosocial values (similar to Self-transcendence). There was no evidence for shared environment effects, and the rest of the variance was accounted for by non-shared environment and error.

A German twin study included two dimensions of values and moral concerns among 555 pairs at the ages of 14–86 (M = 38.84) (Zapko-Willmes, 2018(. Moral concerns of organization versus opportunity and values of Openness to change vs. Conservation loaded on a single factor, which had a 30 % heritability. Together with its additional unique genetic variance, this value dimension showed a genetic effect of about 46 %. In contrast, Self-enhancement vs. Self-transcendence values, which loaded on the same factor as a moral concern of social outcomes versus individual outcomes, showed 34 % heritability. Both Openness to change vs. Conservation and Self-enhancement vs. Self-transcendence values showed substantial shared environment effects (respectively, 33 % and 27 %).

Another German study (Renner et al., 2012) studied 231 pairs at the ages of 27–80 (M = 46.04). Out of 13 values, 11 showed some genetic effects (ranging from 20 to 48%; the exceptions being the values of grace and defense). Interestingly, some values (intellectualism, relevant to universalism, and hedonism) showed also genetic effects that were non-additive (indicated by MZ twins being more similar as compared to DZ twins, than would be expected based on an additive genetic model). Finally, some of the values showed shared environment effects, specifically grace (47 %) and success (32 %).

The sole study that found only weak evidence for genetic influence on values focused on values of materialism, which are conceptually similar to Self-enhancement (Giddens et al., 2009). The study included 240 same-sex twin pairs, at the ages of 18–50 (M = 23.88) from Canada and the U.S.A, who reported their materialism values using three distinct component variables: success, centrality, and happiness in the context of materialism. Contrary to the researchers' expectation, with the exception of happiness, overall materialism and its components, success and centrality, were not found to be affected by genetics. Instead, they showed a meaningful 42–53 % shared-environment contribution. Happiness showed a 46 % genetic contribution but no shared-environment influence.

Another study that showed substantial shared environment effects, in addition to genetic effects, focused specifically on religious values, which are compatible with tradition values and the Conservation higher-order value in Schwartzö (1992) theory. In this study, which is unique in being the only published longitudinal twin study on values, Button et al. (2011) studied a large sample of 2749 individual twins in Colorado in two age waves, 12–18 and 17-29. Interestingly, in the younger age group, religious values showed higher heritability than religious behavior (attendance; 29 % vs. 9 %, respectively). The study's developmental perspective yielded additional intriguing findings. First, there was change with age in the relative importance of genetic and shared environmental contributions. Heritability grew significantly from 29 % to 41 % in the second measurement point, while shared environment effects slightly dropped from 44 % to 37 %. In addition to analyzing genetic and environmental contributions to religious values in each wave separately, the researchers analyzed their effect on stability and change. Religious values correlated substantially across ages (.67). This stability was mainly driven by shared environment factors (67 %) although genetics also contributed to stability (33 %). In contrast, shared environment factors did not contribute to change. Instead, genetics (52 %) and the non-shared environment (48 %) were the drivers of change.

When Button et al. (2011) further split the sample based on age in the first wave, their analyses showed that the effects of the shared environment for stability were more pronounced in younger (12–14 years) as compared to older adolescents (15–18). The younger adolescents, but not the older ones, also showed some contribution of the shared environment to change. In contrast, genetic effects contributed more strongly to both change and stability among older adolescents. Thus, the relative contribution of genetics and the environment varies developmentally, even within adolescence. The overall tendency is for genetics to drive change and increase in importance with age, while the shared environment drives stability, more so in early adolescence than later in development.

Knafo and Spinath (2011) were the first to conduct a twin study of values among children. Participants were 271 German twin pairs at ages 7–11 years (M = 9.09). As is the case with adults across cultures (Schwartz and Rubel, 2005) girls rated Self-transcendence higher than boys and Self-enhancement lower than boys (these sex differences are not large, but are consistent across cultures and age groups). Following Knafo and Schwartz (2009), these values were therefore termed *gender-typed*. In contrast, the other dimension of values (Conservation vs. Openness to change) shows lower or no sex differences, and was referred to as *gender-neutral*. The findings indicate that Self-transcendence versus Self-enhancement (gender-typed) values, had 49 % heritability while Conservation versus Openness to change (gender-neutral) values had lower heritability (34 %, with no shared environment contribution). The rest of the variance was attributed to the non-shared environment, and error.

Importantly, when Knafo and Spinath (2011) divided the sample to boys and girls, heritability estimates for boys in the two value dimensions were similar, 40 % and 44 %. At the same time, among girls there was a dramatic difference, with heritability for gender-neutral values only 28 %, as compared with 55 % for gender-typed values. Further analyses looked at the genetic and environmental contributions of showing gender-atypical values. While boys' tendency to be high on Self-transcendence was accounted for solely by environmental factors, girls' likelihood of being on the Self-enhancement end of this value dimension was strongly accounted for by genetic factors.

Kandler et al. (2016) enlarged the Knafo and Spinath (2011) sample to 805 individual twins (399 complete twin pairs) and added parent data from 388 mothers and 249 fathers. They reported results for 8 of the 10 Schwartz' values (universalism and tradition excluded). Genetic effects were found for 7 of these values (all but security), with effects ranging from 12 % for hedonism to 47 % for achievement. Five values showed modest shared environment effects: conformity, security, and power, three values that are adjacent on the value circle, and hedonism and stimulation, adjacent on the other end of the circle, as shown in Fig. 1). Importantly, adding parents to the design enabled a direct test of the possibility that shared genetic factors, rather than environmental factors, account for the association between parents' and children's values. Finding little evidence for parent-to-child non-genetic influences indicated that genetic relatedness is indeed a key factor in family continuity in values.

The youngest twin sample for which value data are available included 174 pairs of 7 year-old Israeli twins (Uzefovsky et al., 2016). To assess children's values at this young age the authors used a measure recently developed by Döring et al. (2010). The measure presents the values in a concrete manner (with cartoons and short captions) and asks children to rank them into five categories. It has been shown to replicate the Schwartz (1992) structure in children as young as 5-years old (Abramson et al., 2018). Three of the four higher-order values showed genetic effects, and no shared environment effect. Heritability ranged between 29–47 %, with Conservation the lowest and Self-transcendence the highest. For Openness to change a different pattern was found, with no genetic contribution, and a significant (19 %) shared-environment effect.

In conclusion, all studies reported genetic contributions at least to one or more values, as well as non-shared environment and error effects. Some studies showed evidence for shared environment effects for part of the studied values. To summarize the results across all studies of twins reared together, Fig. 2 presents correlations for MZ and DZ twins. For comparison purposes, in each of these studies correlations are aggregated across values representing the Schwartz (1992) higher-order values. Although using higher-order values may lose some important nuances of the value structure, it enables comparing across studies more efficiently (and may present more reliable estimates).

A simple glance at the figure shows that the vast majority of correlations are higher for MZ than DZ twins, as reflected in the genetic effects discussed above. This pattern is especially consistent in Conservation and Self-transcendence values. Importantly, the exceptions to this pattern all appear in Openness to change and Self-enhancement values. No clear explanation to this pattern can be given without additional twin studies, and the exceptions may represent variations in methods, ages and the specific values included in each of the value dimensions. Nevertheless, it is interesting to note that one organizing principle of the value structure (Fig. 1) is that of a social focus (Conservation and Self-transcendence) as compared to a personal focus (Openness to change and Self-enhancement; Schwartz, 2012). Thus, most evidence for the effects of the shared environment (as indicated by non-genetic family resemblance) comes from self-focused values. These results can be seen as in line with a recent experiment using economic trust games with adult female twins (Reimann et al., 2017). While trusting behavior showed a partial genetic effect and no shared environment effect, the self-focused behavior of distrust (manipulated as taking from another person's endowment within an economic exchange game) showed a shared environment effect, but no heritability. The self-other distinction presents an important avenue for future research on the environmental effects on values.

3. Discussion

3.1. The potential neurobiological background of values

Taken together, the twin studies we have reviewed provide substantial evidence for the role of genetics in the development of values. Almost all of the studies showed meaningful genetic effects, at least for part of the values studied. Molecular genetic work on the origin of values is scarce. A single, small-sample study found that genome-wide polygenic scores predictive of the personality trait of neuroticism related in a similar manner to value priorities (Zacharopoulus et al., 2016). As is the case with other complex traits, the genetic contribution

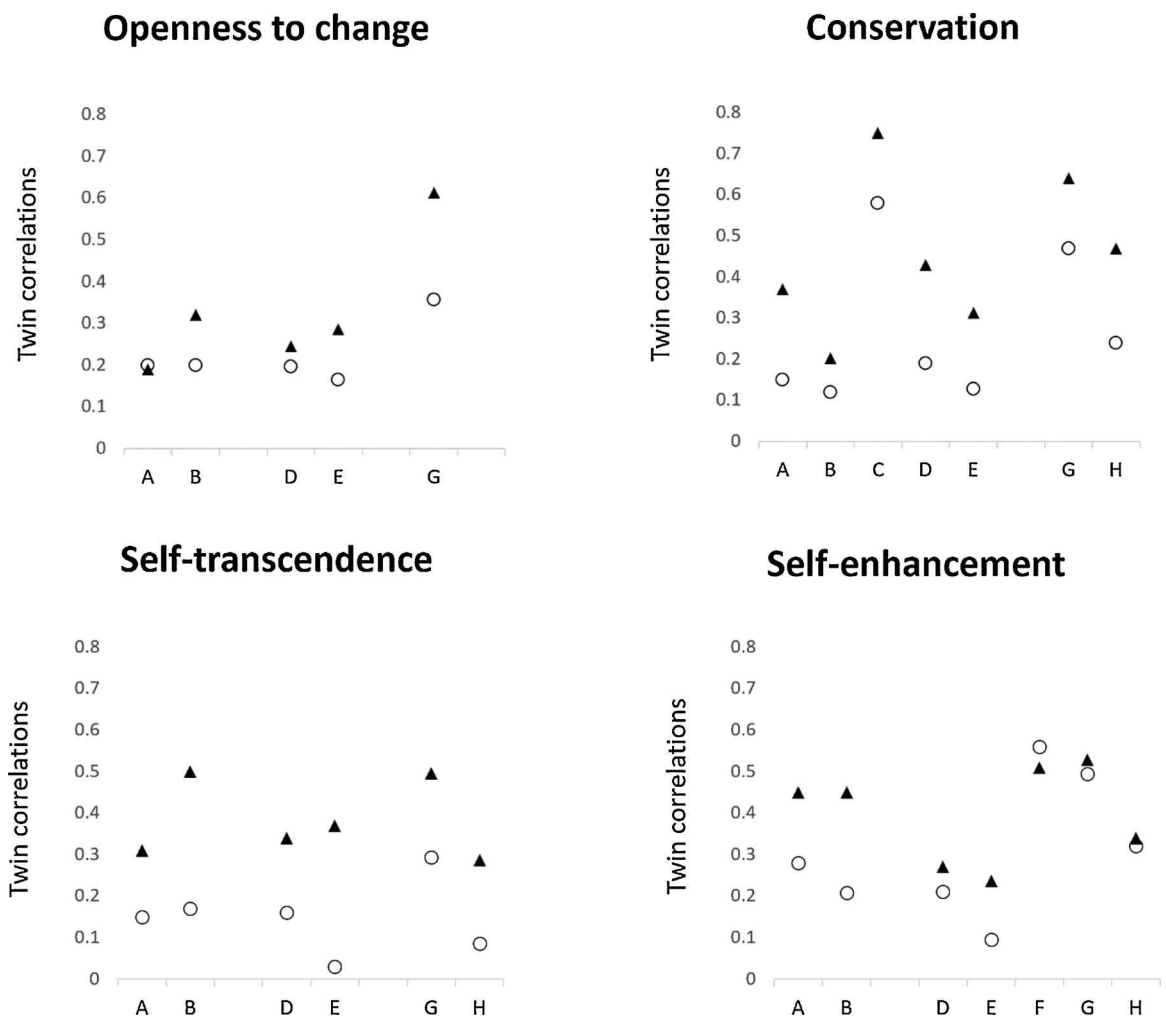

Fig. 2. MZ and DZ correlations in Schwartz's four higher-order values.
MZ and DZ correlations in four higher-order Schwartz (1992) values. ▲ = MZ; ○ = DZ. The studies are presented by age, with the youngest sample (based on average age) on the left and the oldest sample on the right. A = Uzefovsky et al., 2016, B = Kandler et al., 2016, C = Button et al., 2011, D = Schermer et al., 2008, E = Schermer et al., 2011, F = Giddens et al., 2009, G = Zapko-Willmes, 2018 and H = Renner et al., 2012. Samples B, C, D, G and included a small number of DZ-Opposite sex. Correlations for Sample G were provided by A. Zapko-Willmes, personal communication, 6.5.19.

to values is expected to represent the joint input of many genes with small effects (Israel et al., 2015).

Demonstrating the heritability of values does not mean that there are direct genetic effects on values. One way that variability in values may have been achieved is through the effects of evolution on associated behaviors. For example, prosocial behavior is related to the Self-transcendence vs. Self-enhancement value dimension (Abramson et al., 2018; Sanderson and Mcquilkin, 2017). There are benefits to being prosocial, but being too prosocial can put individuals at a disadvantage (Oakley et al., 2012). As circumstances change over generations, and as at times it was beneficial to be prosocial and at other times not, evolutionary pressures may have contributed to variability in prosocial tendencies (Nettle, 2006). Such genetic variability contributing to diversity in behaviors may have contributed to diversity in associated values (e.g., the importance of benevolence).

The genetic contribution to values suggests a biological infrastructure to the preference of certain values over others. There has been surprisingly little research on the topic (for pioneering studies, see Brosch et al., 2011; Crockett et al., 2017; and Zacharopoulos et al., 2017). The few available studies indicate associations between individual differences in brain processes and human values. However, much more research is needed. There is little knowledge of the brain mechanisms which are associated with values, but we can speculate such factors will be involved. Further research is needed to examine the brain regions and gene networks associated with values. Up until now, these topics have been investigated separately and independently. Neurobiological studies of values that in addition will examine the genetic contribution to these brain mechanisms will improve our knowledge and deepen our understanding of the neuroscience of values.

3.2. Interpreting the environmental contribution to values

As would be expected, all twin studies found substantial environmental contributions to individual differences in values. These effects were largely due to the non-shared environment, whose relative contribution, which includes measurement error, ranged from 24.5 to 85.7%. In contrast, the shared environment was much less influential, with effects ranging from 0 % for most values in most studies to 52 % for materialism-happiness values in Giddens et al. (2009). In sum, although the effects of the environment are unequivocal, twin study results suggest that it does not make the values of family members more similar but contributes to the differences among them.

The small and inconsistent shared environment effects raise the question of whether it is possible that the environment in which individuals grow up has no influence on human values? And how does

this align with past work demonstrating the roles of variables such as parenting, SES and the family environment (Hitlin, 2006; Schwartz, 2006a)? We provide a manifold answer to this question.

First, it is important to note that some of the influence of parents on their children may operate at the culture level (Knafo-Noam et al., 2020). Significant, though not necessarily very strong, cultural differences in values have been shown repeatedly (e.g., Schwartz and Rubel, 2005; Schwartz, 2006b). Cross-cultural research has shown that across cultures parent–child value similarity reflects the effects of shared national and ethnic values (Barni et al., 2014). As twin studies typically focus on individuals within the same broad cultural context, they cannot detect the effects of culture-level family influences.

Second, in their search for estimating genetic and environmental contributions, twin studies typically rely on a dichotomous distinction between heritability and environmental influences. However, this assumption ignores the fact that genetics and the environment do not operate independently. There are several aspects of the interplay between genetics and environment, that are relevant for understanding the findings of the reviewed studies (for a review of this topic as it applies to the broader issue of socialization, see Avinun and Knafo-Noam, 2015).

Significant, it is important to note that parents, who share their genes with their children in most families, often also provide the value environment for these children. To the extent that the shared genetics are relevant to values, this creates an overlap between genes and the socializing environment, in what has been termed a *passive gene-environment correlation (*Kendler and Baker, 2007; Plomin et al., 2008). Parents who adapt their value messages to their children based on the children's tendencies end up having children who accept their values to a greater extent (Grusec and Goodnow, 1994). And thus, the congruence between genotype and environment may increase children's likelihood of internalizing their parents' values (Knafo-Noam et al., 2020).

Another possible explanation concerns *evocative gene-environment correlation*, when environmental responses are evoked by the developing person's genetically-influenced phenotype (Avinun and Knafo-Noam, 2015; Jaffee and Price, 2007). Although there is little research on the topic, there is some evidence that children's values affect those of their parents (Knafo and Galansky, 2008; Pinquart and Silbereisen, 2004). In addition, children's genetically-influenced behavior might evoke in their parents and other people specific environmental inputs (e.g., parenting behaviors) congruent with their genetics (Avinun and Knafo, 2014; Klahr and Burt, 2014). Such evocative gene-environment correlations may account for the tendency of genetic influences to increase in importance with age (Beam and Turkheimer, 2013; Bergen et al., 2007). To the extent that the environment reacts to the child, the child grows up surrounded by an environment that is increasingly congruent with his or her genetic tendencies. In this sense the increased genetic effect actually shows also the effects of the environment. The only published longitudinal twin study of values does show an increase in heritability with age (Button et al., 2011).

Finally, *gene-environment interactions* (GxE) might be involved too. In GxE the environment affects differently, by magnitude or direction, people who differ in their genetics. In other words, genetics is a moderating factor of the environmental influence. Children in the same family might be affected differently by the family environment, because of variety in their genetics (Belsky and Pluess, 2009; Caspi et al., 2002). In other words, factors often conceived of as family-level variables (shared environments), such as parental values and parenting, may operate in interaction with genetics. Such effects will be subsumed in the non-shared environment factor (Turkheimer and Waldron, 2000). Research on GxE and values is greatly needed.

3.3. Future directions

Twin research of values is in its infancy, including less than a dozen published studies. Nevertheless, it provides us with important information about the formation of values, particularly the somewhat controversial role of genes in values. Genetically-informative studies of values that go beyond the twin studies, such as adoption and GWAS studies, will help understand the role of genetics further. Parents provide children's first value environment through their socialization efforts, and through placing children in environments such as schools and neighborhoods that may affect their values; at the same time parents may also indirectly affect children through their shared genotype (Knafo-Noam et al., 2020). Because of the inherent complexity of the topic, it is recommended that twin studies of values include meaningful measures of the environment, such as parenting and parent values, in order to directly address issues of gene-environment correlation and interaction.

Although the reviewed twin studies covered countries as varied as Israel, Australia and Germany, they all came from relatively affluent and modernized societies. More twin studies from a broader range of cultures are needed. Despite representing a broad range of ages, most studies did not take a developmental approach. It is increasingly acknowledged that values emerge before adolescence (Cieciuch et al., 2013; Döring et al., 2016). More work on children's values, hopefully longitudinal and covering the important transition to adolescence, is needed. Similarly, there are meaningful changes in value priorities towards older age (Gouveia et al., 2015; Inglehart, 2008; Robinson, 2013), and a twin study covering transitions associated with change of values in light of the changing needs of older adults would be very informative. Moreover, the studies were conducted on different ages and in some cases on a very wide range of ages. There is evidence that the effect of genetics increases with age while that of the shared environment decreases with age (Bergen et al., 2007); the only longitudinal twin study on values provides evidence for a similar trend (Button et al., 2011). Thus, more twin studies on values are needed in different ages, and preferably using longitudinal designs.

The evidence for the role of genetics in individual differences in values may be seen as one explanatory pathway for the effects of genes on attitudes, defined as emotional reactions, beliefs, and behavioral tendencies toward objects, events, issues, and people (Petty and Brinol, 2010). The association between values and attitudes has been established. For example, political attitudes correlate meaningfully with values (Schwartz et al., 2010). People with right-wing attitudes give high importance for security, conformity, power and achievement, whereas left-wing attitudes are correlated with high importance of universalism, benevolence and self-direction values (Caprara et al., 2006). Attitudes have been shown to be partly heritable (Olson et al., 2001; Tesser, 1993), with studies showing genetic contributions to attitudes towards issues such as religiosity (Eaves et al., 2008; Vance et al., 2010), abortion (Eaves and Hatemi, 2008), risk taking (Anokhin et al., 2009; Miles et al., 2001) and political positions (Hatemi et al., 2014, 2011; Hatemi et al., 2007; Klemmensen et al., 2012). While it is possible to speculate that evolutionary pressures may have led to variability in basic human values (or their underlying neurobiological systems), genes "for" attitudes related to political positions, for example, are unlikely to have evolved in the brief evolutionary time that has passed since relevant political discussions were introduced. A more realistic model is one in which genetic influences support more basic values, which in turn affect attitudes. A multivariate design focusing on the genetic correlations between values and attitudes will expand the existing knowledge in both values and attitudes, and possibly describe the role of the genetics of values in the heritability of attitudes.

Values have been shown to relate meaningfully to behavior (Roccas and Sagiv, 2010; Vecchione et al., 2016). A single genetic study has shown genetic effects on both religious behavior and religious values (Button et al., 2011). It would be an important direction for future research to relate behaviors to values in the same design and investigate the role of genes in the value-behavior association.

Similarly, twin research on the association between values and traits

would contribute to our understanding of the development of values. There are consistent associations between values and traits (e.g., achievement values and the Big-5 trait of extroversion; Fischer and Boer, 2015; Roccas et al., 2002). Do these associations rely on overlapping genetic factors or on environmental factors that affect both values and traits? A single twin study relating values to personality traits has shown promising evidence (Schermer et al., 2011). For example, security values have been shown to share their contributing genetic variance with impulsivity, as did conformity with succorance. Some weaker evidence was found for the overlap between environmental factors related to values and traits (e.g., security and harm avoidance; Schermer et al., 2011). In future work, it would be of major interest to see if endophenotypes involved in personality traits (Congdon and Canli, 2005; Deris et al., 2017) are also involved in associated values. This could help identify the process through which genetics influence human values.

Although such multivariate genetic work linking personality traits and values (Schermer et al., 2011) could be very informative, we note that values and traits are different constructs as evident from their modest correlations (which, on average, rarely exceed .40 in absolute value; Fischer and Boer, 2015; Parks-Leduc et al., 2015). Several differences between traits and values could affect their development differently. While traits describe individuals in terms of relatively consistent aspects of how they behave and feel, values describe the motivational aspect of personality, and specifically what is important to people (Parks-Leduc et al., 2015; Roccas et al., 2002). As such, values require a degree of self-reflection which emerges later than individual differences in affect and behavior (McAdams and Olson, 2010). Having a specific value means, by definition, that it is desirable, whereas traits may be more or less desirable, leading individuals to desire change in their traits more than in their values (Roccas et al., 2014). This is reflected in parents wanting their children to have values similar to their own (Benish-Weisman et al., 2013; Whitbeck and Gecas, 1988). In contrast, parents may not necessarily want their children to adopt their personality traits. Finally, while people often acknowledge the importance of genetics to traits and behaviors (Dar-Nimrod and Heine, 2011), values are often perceived as a moral aspect of development with parents responsible for its development (Smetana, 1999; Walker et al., 2000). These differences between values and traits may have potentially competing developmental implications. Thus, as shared environment effects tend to decrease with age (e.g., Haworth et al., 2010; Knafo and Plomin, 2006), smaller shared environment effects may be expected for values that emerge later than traits. On the other hand, the importance of values to parents, and their social role as socializers of values may mean more effort is put on socialization of values, potentially leading to stronger shared environment effects on values. The varying levels of shared environment effects across values (Fig. 2) suggest that these competing processes may operate differentially for different values.

Moreover, research on value-trait associations suggests that the role of genetics in values may change with development. Recent longitudinal work suggests that personality traits predict change in values more strongly than values predict change in traits (Fetvadjiev and He, 2019; Vecchione et al., 2019). If indeed, with development values become increasingly reflective of individuals' traits, the genetic contribution to traits may lead to values becoming increasingly heritable with age (Button et al., 2011). Longitudinal genetic research on values and traits may be informative for understanding the dynamics of personality.

3.4. Conclusions

In this article we reviewed the available twin studies concerning human values. Further research is needed to support the conclusions of the present study, given the small number of available twin studies. Nevertheless, the reviewed literature includes consistent findings such as the presence of genetic effects in all of the studies. The picture which emerged from the review challenges the prevalent perception that attributes value development solely to the socialization process. Our review indicates that similarity in values among parents and their offspring is, at least in part, the result of the genetic heritage shared by family members (Kandler et al., 2016). More research is needed to understand the specific biological pathways from genes to values. Polygenic work is needed to understand the genes involved, without relying on the assumptions of the twin design. Finally, multivariate work linking genetics to values through possible endophenotypes is needed.

The findings of the current review might be interesting and useful for parents and educators. Values are not solely the result of the environment to be shaped simply by appropriate socialization, and individual differences in children's tendencies should be appreciated by parents and educators. Thus, when parents or educators want to encourage a child for desired behavior or achievement, they should find a way to relate to the child's values as well.

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